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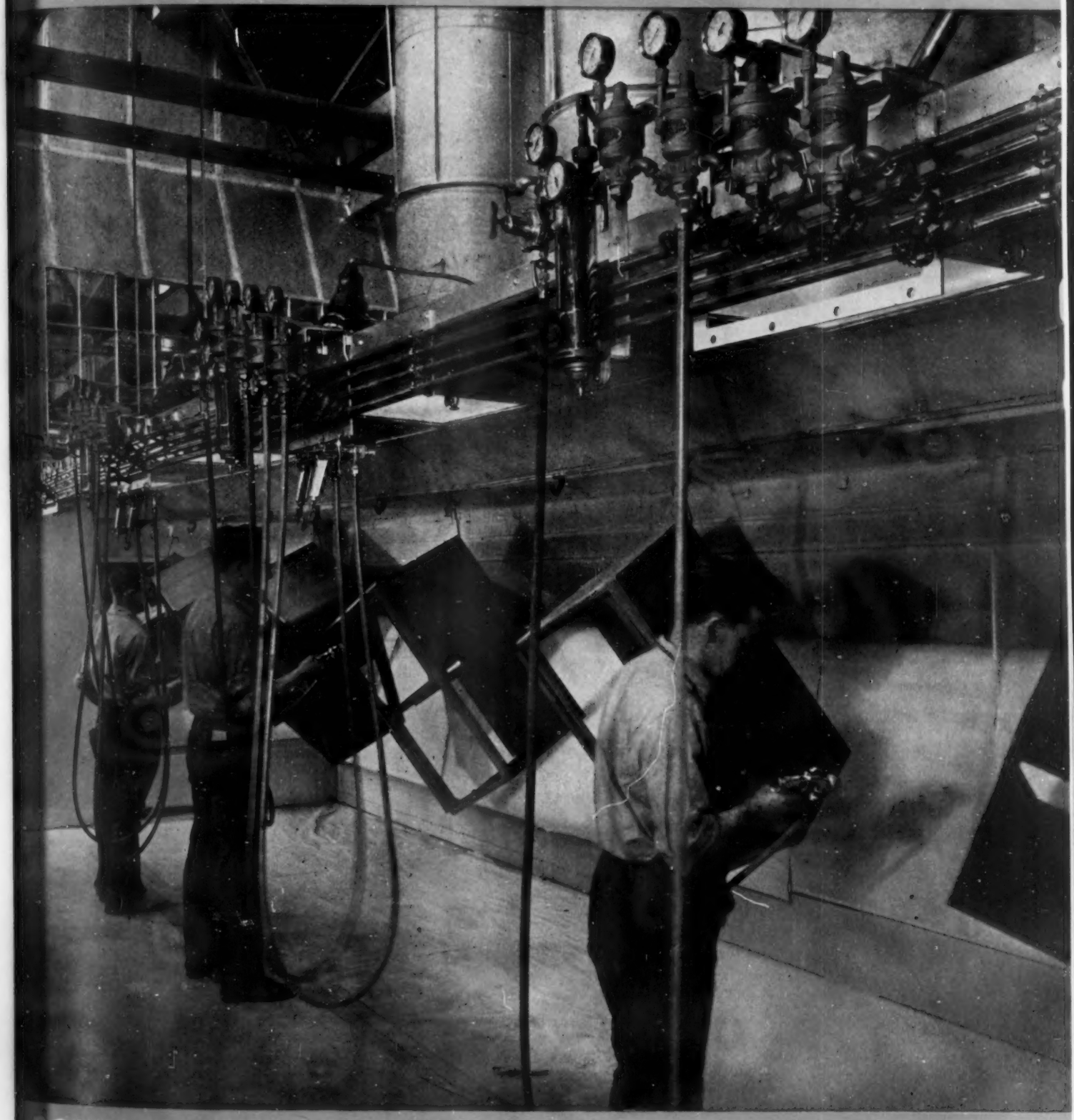

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Tung Oil

Tung or Chinawood oil, the fast-drying oil used in organic finishing materials, has become extremely scarce due to the war in the Far East. The expression "tung oil" refers to the Chinese word for heart because of the heart shaped leaves of the tung tree. The oil is obtained by pressing the kernels of the tung nut which is about the size of a small apple, and usually contains about five seeds or kernels. Our normal annual consumption of tung oil is over 150,000,000 lb., and the paint and varnish industry takes 75% of this amount.

The difficulty of obtaining tung oil abroad has focused attention on tung tree culture in the United States. The first tung seeds were sent to this country in 1902 and the oldest surviving trees were planted in 1906. Extensive planned and haphazard studies took place from 1906 until 1930. In 1930 the plantings amounted to approximately 4300 acres, and in 1939, they increased to 175,000 acres. The tung trees require a special type of soil and climate, which, unfortunately, limits their growth to a region not over 100 miles wide along the Gulf Coast. They require a prolonged dormant period but unfortunately can withstand only a few days of freezing temperature a year. They require a heavy rainfall of the order of 40 to 50 inches a year, but in spite of this, they must be planted where the water table is lower than 20 feet from the surface of the soil.

Modern production methods have enabled the obtaining of tung oil at a cost as low as 5 cents per pound, and the quality of the tung oil produced from domestic trees has proved to be superior to the Chinese product. Unfortunately, at the present time we are only producing a small fraction of our total requirements of tung oil, but the urgent demand is hastening expansion of our tung oil producing facilities.

L. H. LANGDON, *Publisher* • T. A. TRUMBOUR, *Business Manager* • DR. WALTER R. MEYER, *Editor*

Anodic Treatment of Aluminum in the Chromic Acid Bath*

O. F. TARR, MARC DARRIN, and L. G. TUBBS

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CHROMIC acid has extensive uses in the anodic treatment of aluminum for all U. S. Naval aircraft. Uncertain and inefficient operation has resulted in many instances from lack of data regarding the factors influencing the process. In this report complete fundamental data are presented for the first time showing the relationship between corrosion resistance, film weight and thickness, current density, concentration and pH of the chromic acid bath, temperature, time of treatment, electrical and practical efficiencies, chromic acid economy, alumina dissolved, cathode area, throwing power, etc., in the treatment of aluminum and some of its alloys. From these data may be calculated the most economical procedures which will give satisfactory films under various operating conditions.

Laboratory Procedure

Triplicate sets of aluminum and aluminum alloy panels measuring 2 × 4 inches were treated anodically at 40 volts. The chromic acid baths were agitated by blowing with air, and were regulated thermostatically by means of a cooling coil and an electric heater, at the temperatures indicated to within ±0.2° F. Ampere-hours were determined by copper coulometer measurements. The current densities accordingly are the true averages. In most tests full voltage was applied immediately. In some tests voltage was brought up over a period of about 5 minutes, but no differences were noted other than those due to slightly different amounts of current passed. No attempt was made to study the empirical voltage cycle employed by Bengough and Stuart (*2*).

The panels anodically coated were alloy 17ST (4.0 per cent Cu, 0.5 per cent Mn, 0.5 per cent Mg), alloy 24ST (4.2 per cent Cu, 0.5 per cent Mn, 1.5 per cent Mg), and Alclad 24ST (*1*). The latter is a "sandwich" sheet consisting of alloy 24ST between two very thin sheets of high-purity aluminum. This coating not only protects the alloy which it covers, but by electrolytic action prevents attack on the sheared edges of the base alloy (*1*).

Baths were prepared from technical chromic acid (over 99.8 per cent CrO_3) and analyses checked by electrometric titration with a standardized ferrous sulfate solution. Baths containing alumina were prepared by dissolving pure aluminum powder in chromic acid solutions, followed by electrolytic regeneration of the trivalent chromium. A Beckman meter standardized against pure chromic acid solutions was used for determination of pH values. Any glass electrode meter may be used for measuring the pH of chromic acid solutions, but for accurate work the individual meter should be calibrated against chromic acid solutions of known composition (*8*). Baumé values were calculated from specific gravities determined by the pycnometer method (all weights in air) using a constant-temperature bath. Unless otherwise indicated, the cathode area was 1/25th the area of the anode. Precautions were taken to avoid the presence of trivalent chromium.

After anodic treatment, the panels were washed in cold water, dried at 260° F. for 30 minutes, and weighed. The anodic films then were stripped from one set of panels in a phosphoric-chromic acid bath at 212° F. for 5 minutes. The stripping bath was made by dissolving 20 grams of chromium trioxide and 35 cc. of 85 per cent *o*-phosphoric acid in 1 liter of water (*5*). After stripping, the panels were washed, dried, and weighed. This operation was repeated until a constant weight was obtained. Two 5-minute strippings usually were sufficient to remove the oxide film completely. No measurable amount of aluminum metal dissolved in this stripping bath during a 5-minute period. Suitable precautions were taken to avoid absorption of moisture by the anodic film while weighing.

†Reprinted from "Industrial and Engineering Chemistry," Dec., 1941.

One set of treated panels was used for salt-spray corrosion tests; the remaining set was reserved for checking purposes. A large number of sets of panels were prepared with the electrolyte at various pH values over the indicated range, at intervals not further apart than about 0.1 pH. The principal tests were run for 30 minutes at 95° F. with Alclad 24ST, and with the alloys most commonly used for aircraft, 24ST and 17ST, using baths containing 100 grams per liter of total chromic acid, free and combined. This concentration is referred to as a "10 per cent bath", but the percentage by weight is 9.3 per cent chromium trioxide in a new bath. Some tests were run also in "7.5 per cent", "5 per cent", "2 per cent", and "1 per cent baths". A complete series of tests was run for Alclad 24ST in a 10 per cent bath at different temperatures. The effect of other miscellaneous variables was determined by special anodic treatments which were run in a similar manner.

Salt-spray tests were run in the customary manner for 30* consecutive days at 95° F., using a 20 per cent salt solution and supporting the test panels from the base at an angle of 30° from the vertical. The salt-spray test is an arbitrary criterion of corrosion and specimens showing corrosion are usually subjected to tensile strength tests (*11*). In the present tests, manifestations of corrosion were evaluated by visual methods (*4*).

The criterion of passage of the salt-spray test was: no failure of the film, except that one or two small pits were disregarded if they appeared to be due to mechanical injury. Panels which passed the salt-spray test are shown by the solid circles on the lower curves in Figure 1. A few panels which did not pass the salt-spray test are indicated on the same lower curves by open circles. Many satisfactory panels were obtained close to these few scattered instances of failure. Examination under low magnification indicated mechanical injury of the film on those that failed.

Calculations

The difference in weight of a treated panel, before and after stripping, is the weight of the anodic film. It is recorded in the tables (column J) as milligrams of alumina per square inch. Measurements indicate that its average thickness (K) expressed in mils (0.001 inch) is 1/50th of the weight expressed in milligrams per square inch. This relationship between thickness of anodic film and its weight corresponds to results obtained by other investigators (*5*). The small amounts of alloying constituents present in the alloys were disregarded, and the difference in weight of the panel, before anodic treatment and after stripping, taken as the weight of aluminum oxidized to alumina. It is recorded as milligrams of alumina per square inch (I). The difference between alumina formed and that in the anodic film is the alumina which has gone into solution in the chromic acid bath. This difference divided by the number of ampere-hours, as determined by the copper coulometer, gives the milligrams of alumina dissolved per ampere-hour (P).

The weight of the anodic film, divided by the weight of the total alumina formed, is taken as the practical film efficiency (L). The current density (M) is the average amper-

*Since this work was started, revised specifications (*10*) have reduced the salt spray exposure from 30 days to 250 hours.

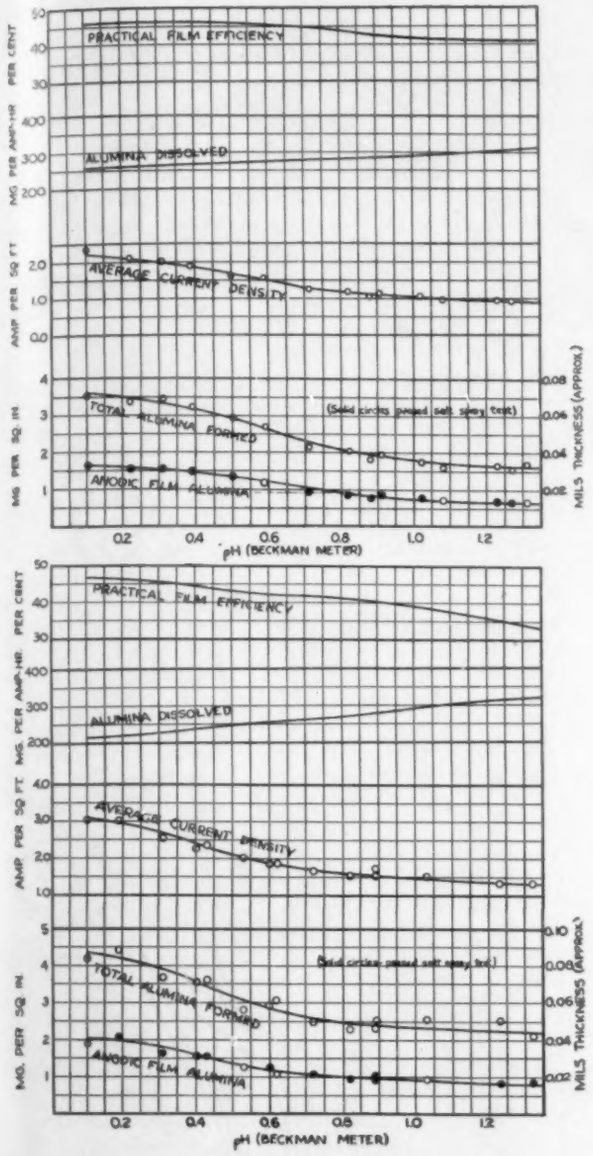

FIGURE 1. ANODIC COATING CHARACTERISTICS FOR ALLOY 17ST (*above*) AND ALLOY 24ST (*below*)

100 grams per liter CrO_3, free and combined (10 per cent bath) 30 minutes, 95° F., 40 volts

age, as calculated from the coulometer determination, divided by the area in square feet. The apparent electrical efficiency (N) is the total aluminum oxidized divided by the theoretical as calculated from its electrochemical equivalent. For Alclad products it may be a little higher than the true electrical efficiency, since it does not take into account a small amount of metal which may be dissolved directly from the anode by chemical action; but in the case of the alloys studied, the recorded electrical efficiencies are somewhat lower than the true values, because of disregarding the effect of the alloying constituents.

The ratio of combined chromium trioxide to alumina (B) in various baths and the concentration of free chromic acid (C) were calculated from analyses and pH readings (*7, 8*). The weight of film per pound of introduced chromic acid (R), when treating at a maintained pH, was calculated from the composition of the bath and the anodic characteristics as indicated in Table I. The weight of film (V), for batch operation, was found by summation of film weights for increments of two-tenths increase in pH. The square feet of surface treated per pound of chromic acid (S, W) was calculated in a similar manner. Other relationships are shown by equations in Table I. Because of "drag-out" and other handling losses, the chromic acid consumption would be higher in practice for batch operation than the calculated results; but no allowance is required for these losses when operating at a maintained pH, since the drag-out and other losses are less than the "draw-off" which is required to maintain the pH.

Fundamental Data

Table I shows complete anodic coating characteristics for Alclad 24ST for 30 minutes under the conditions indicated. Table II shows in an abbreviated form similar data for 60 minutes. This and other abbreviated tables may be expanded by similar calculations. Table III shows anodic coating data for aluminum alloys 17ST and 24ST. The curves and charts correspond to these fundamental data, or were derived from similar data not included in this report.

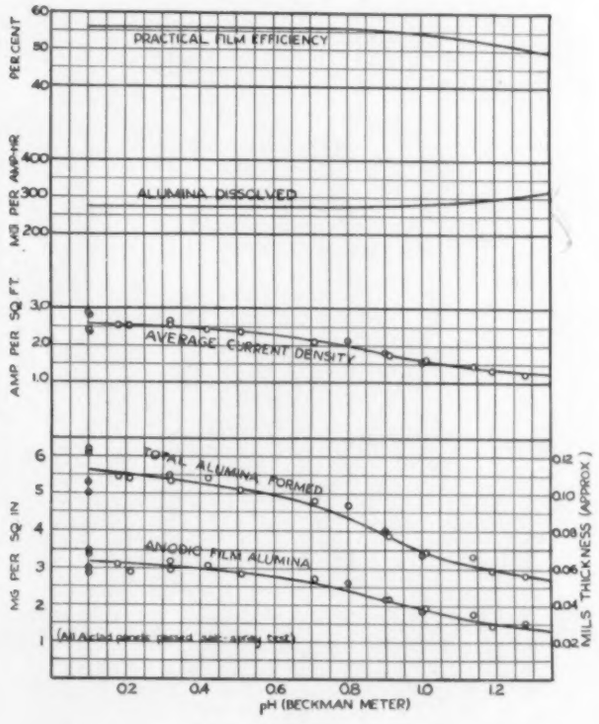

FIGURE 2. ANODIC COATING CHARACTERISTICS FOR ALCLAD 24ST

100 grams per liter CrO_3, free and combined (10 per cent bath), 30 minutes, 95° F., 40 volts

Figure 2 shows in graphic form the basic anodic coating characteristics of Alclad products; Figure 1 shows similar data for aluminum alloys 24ST and 17ST. These charts comprise smoothed-out curves. There are simple mathematical relationships between all points on each set of curves, as shown by the equations in Table I, and in smoothing-out experimental variations, advantage was taken of these relations. These curves agree very well with the experimental points and at the same time conform to known relationships. The only curve which might be drawn in a little different manner is for Alclad 24ST in the neighborhood of a pure chromic acid solution (Figure 2). At this point two series of values were obtained, one set below the

TABLE I. ANODIC COATING CHARACTERISTICS FOR ALCLAD 24ST[a]

[At various pH 30 minutes at 95° F. and 40 volts, in a bath containing 100 grams per liter CrO_3, free and combined (10% bath)]

	Composition of Bath[b]						Anodic Coating Characteristics at Maintained pH[c]								To Various pH[d]			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W
pH at 25° C.	Baumé at 60° F.	Grams per cc. at 25° C.	Ratio of combined CrO_3 to Al_2O_3	Free CrO_3 in bath at 25° C., g./l.	Free CrO_3 in bath, wt. %	Free CrO_3 basis, total CrO_3, wt. %	Combined CrO_3 basis, total CrO_3, wt. %	Al_2O_3 per lb. combined CrO_3, lb.	Al_2O_3 per lb. total CrO_3, lb.	Al_2O_3 formed, mg. per sq. in.	Al_2O_3 in film, mg. per sq. in	Film thickness, mil	Practical film efficiency	Current density, amp./sq. ft.	Apparent electrical efficiency	Al_2O_3 dissolved, mg. per amp.-hr.	Film per Lb. CrO_3 Basis of combined CrO_3, lb.	Film per Lb. CrO_3 Basis of total CrO_3, lb.	CrO_3 Basis of total CrO_3, sq. ft.	Increment, lb.	Summation, lb.	Total CrO_3 Increment, sq. ft.	Summation, sq. ft.
0.1	9.8	1.072	[c]	100	9.3	100.0	0.0	[b]	0.000	5.63	3.15	0.063	0.56	2.58	0.99	277	0.288	0.062	63	0.062	0.062	63	63
0.2	10.3	1.076	4.52	78.5	7.3	78.5	21.5	0.226	0.049	5.53	3.10	0.062	0.56	2.54	0.99	276							
0.3										5.44	3.05	0.061	0.56	2.51	0.99	274							
0.4	11.1	1.082	4.83	49.5	4.6	49.5	50.5	0.209	0.106	5.36	3.00	0.060	0.56	2.47	0.99	275	0.266	0.134	141	0.073	0.135	75	138
0.5										5.18	2.90	0.058	0.56	2.38	0.99	276							
0.6	11.6	1.086	5.16	31.0	2.9	31.0	69.0	0.198	0.137	5.00	2.80	0.056	0.56	2.31	0.99	274	0.252	0.174	196	0.038	0.173	41	179
0.7										4.72	2.65	0.053	0.56	2.17	0.99	275							
0.8	12.0	1.089	5.41	19.5	1.8	19.5	80.5	0.188	0.151	4.36	2.45	0.049	0.56	2.00	0.99	275	0.239	0.192	247	0.018	0.191	21	200
0.9										3.90	2.15	0.043	0.55	1.80	0.99	280							
1.0	12.2	1.091	5.58	12.2	1.1	12.2	87.8	0.183	0.161	3.42	1.85	0.037	0.54	1.57	0.99	288	0.215	0.189	322	0.012	0.203	18	218
1.1										3.21	1.70	0.034	0.53	1.50	0.98	290							
1.2	12.4	1.092	5.68	7.6	0.7	7.6	92.4	0.180	0.166	2.98	1.55	0.031	0.52	1.37	0.99	300	0.195	0.180	366	0.006	0.209	11	229
1.3										2.80	1.40	0.028	0.50	1.30	0.98	310							

[a] A limited number of experiments with commercially pure aluminum panels showed similar relationships.

[b] $D = \frac{C}{10A}$, $E = \frac{100C}{C_1}$, $F = 100 - E$, $G = \frac{1.02}{B}$, $H = \frac{FG}{100}$.

[c] $K = \frac{J}{50}$, $L = \frac{J}{I}$, $N = \frac{0.228I}{M \times \text{hours}}$, $P = \frac{144(I - J)}{M \times \text{hours}}$, $Q = \frac{GL}{1 - L}$, $R = \frac{FQ}{100} = \frac{HL}{1 - L}$, $S = \frac{3150R}{J}$.

[d] $T_1 = \frac{(H_1 - H_2)L_2}{1 - L_2}$, etc., $U = T_2 + T_1 \ldots$ etc., $V_1 = \frac{3150T_1}{J_2}$, etc., $W = V_2 + V_1 \ldots$ etc.

[e] For first increment of Al_2O_3, B = 4.26, G = 0.235.

curve and the other set above the curve, but further apart than normal experimental variation. Special precautions, including the use of recrystallized C. P. chromic acid of exceptional purity, did not eliminate this variation.

Derived Data

Figure 3 gives chromic acid consumption charts, which show the weight of anodic film and the area treated per pound of chromic acid introduced when maintaining the bath at the indicated pH, compared to that obtained when starting with a new bath and operating to various pH (batch operation), for Alclad 24ST and alloys 24ST and 17ST, using 10 per cent baths at 95° F. and 40 volts for 30 minutes. Similar relations were found for different periods of treatment. The pH for maximum economy of chromic acid changed for different concentration baths, as shown in Figure 4. Comparisons of optimum pH for different alloys are shown in Figure 5.

Discussion and Recommendations

CORROSION RESISTANCE. A primary purpose of the anodic treatment of aluminum for naval aircraft is to promote a strong bond for the zinc chromate primer. There appears to be no important advantage in a thick anodic film other than additional protection prior to priming. The thinnest film which will stand up under the specified salt-spray test is the most economical, but its merit cannot be judged by appearance—for instance, transparency or color of film are not criteria of corrosion resistance, and the presence of small amounts of sulfate or other minor impurities in the bath may change the appearance of the film to a considerable extent without injuring it. In general, properly produced films on the aluminum alloys most commonly used for aircraft stood up under the salt-spray test when their weight was not less than 0.6 to 1.0 mg. per square inch. The most economical procedures for obtaining this weight of film under different operating conditions may be calculated from the anodic coating characteristics.

CURRENT DENSITY. When Alclad products or alloys 24ST or 17ST were treated for 30 minutes at 40 volts and 95° F. in a chromic acid bath, with or without the presence of dissolved alumina or trivalent chromium, the thickness and weight of the anodic film for each individual metal were almost directly proportional to the current density. This relationship was nearly independent of ordinary variations in concentration, pH, and temperature of the bath, but it was quite different for different metals. A similar relationship was found to exist between current density and total aluminum oxidized. It follows mathematically that the same relations apply to alumina dissolved; and, for equal periods of treatment, it is almost proportional to the ampere-hours of current.

CONCENTRATION AND pH OF CHROMIC ACID BATH. When treating for 30 minutes under the conditions indicated in Figures 1 and 2, there was only a small change in the film thickness for variations in pH near 0.1, or above 1.1, but a considerable change for intermediate points usually between pH 0.4 and 1.0. Ranges were a little different for different alloys and for different periods of time. Within ordinary limits, the concentration of the bath did not affect the weight of the film, except as it affected the pH. The chromic acid consumption, however, was influenced by the concentration. At concentrations below 2.5 per cent the practical film efficiency dropped very rapidly. In a 1 per cent bath at 95° F. for 30 minutes, the practical film efficiency was 0.28 for alloy 24ST. Although characteristics vary for different conditions, the general indication is that 2.5 per cent is the lowest concentration at which a reasonable chromic acid economy may be obtained.

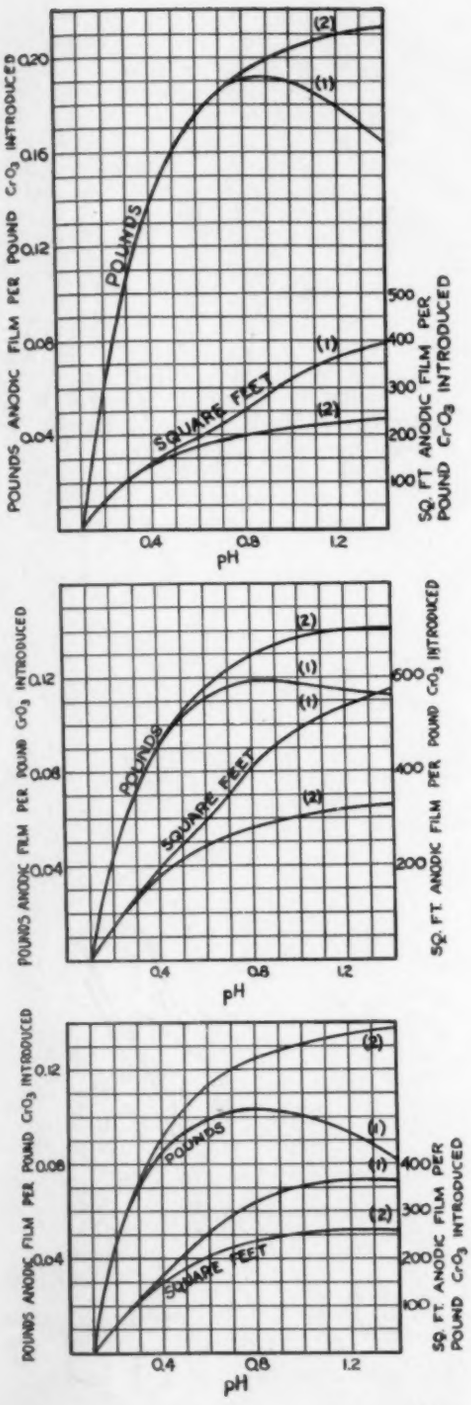

FIGURE 3. CHROMIC ACID CONSUMPTION CHARTS FOR ALCLAD 24ST (*upper*), ALLOY 17ST (*center*), AND ALLOY 24ST (*lower*)

100 grams per liter, free and combined (10 per cent bath), 30 minutes, 95° F., 40 volts

(1) At a maintained pH, (2) batch operation

It is commercial practice to treat by the batch method, and discard the bath when the pH increases to about 0.9, although some may continue until the pH reaches 1.4 or more (9). Under these conditions the character and thickness of the film are continually changing, and although it may be satisfactory throughout the range, it is only toward the end of the run that operation approaches a condition of maximum economy (Figures 3 and 4).

APPARENT ELECTRICAL EFFICIENCY. For commercially pure aluminum and Alclad products, the apparent electrical efficiency approached the theoretical value, as shown in Tables I and II. (Commercially pure aluminum sheet is designated by the Aluminum Company of America as 2S, and analyzes over 99 per cent aluminum. The surface of Alclad products is essentially pure aluminum.) Others (6) have reported apparent efficiencies a little over the theoretical value. For aluminum alloy 17ST the electrical efficiency dropped to about 0.8; and for alloy 24ST it dropped to about 0.7. The apparently lower electrical efficiencies when treating the alloys may be due to disregarding the electrical energy used in oxidizing small amounts of copper and other alloying constituents. The electrical efficiency with the alloys tended to increase with increase in the pH of the bath (Table III).* Variations in electrical efficiencies affect the cost of power, but have no other important effect on the process.

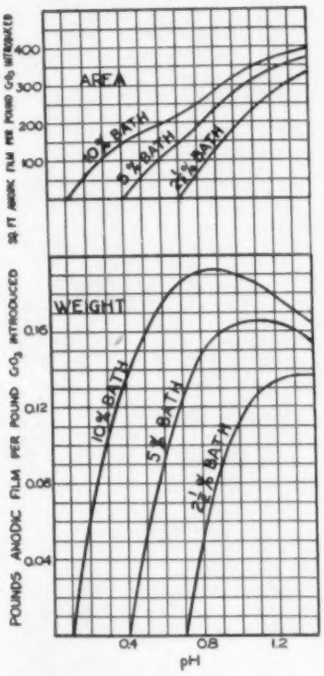

FIGURE 4. CHROMIC ACID CONSUMPTION AT DIFFERENT CONCENTRATIONS

Alclad 24ST at various maintained pH values, 30 minutes, 95° F., 40 volts

PRACTICAL FILM EFFICIENCY. For commercially pure aluminum, or Alclad products, treated for 30 minutes at 40 volts at 95° F. in 10 per cent chromic acid, either with or without dissolved alumina or trivalent chromium, the practical film efficiency varied from 0.56 to 0.50 as the pH increased from 0.1 to 1.3 (Table I). For 60 minutes' anodic treatment the efficiency was a little lower (Table II). For alloy 17ST the efficiency

TABLE II. ANODIC COATING CHARACTERISTICS FOR ALCLAD 24ST

[60 minutes, at maintained pH, 95° F. and 40 volts, in a bath containing 100 grams per liter CrO_3, free and combined (10% bath)]

pH	I Total Alumina Formed, Mg./ Sq. In.	J Anodic Film, Mg./ Sq. In.	L Practical Film Efficiency, $\frac{J}{I}$	M Current Density, Amp./ Sq. Ft.	N Apparent Electrical Efficiency	P Alumina Dissolved, Mg./ Amp.-Hr.
0.1	12.05	6.50	0.54	2.79	0.99	285
0.2	11.85	6.40	0.54	2.75	0.98	285
0.3	11.65	6.30	0.54	2.69	0.99	280
0.4	11.35	6.15	0.54	2.63	0.98	285
0.5	10.95	5.90	0.54	2.52	0.99	289
0.6	10.45	5.65	0.54	2.42	0.98	286
0.7	9.80	5.30	0.54	2.27	0.98	285
0.8	9.00	4.85	0.54	2.09	0.98	286
0.9	8.20	4.35	0.53	1.93	0.97	287
1.0	7.30	3.85	0.53	1.71	0.97	290
1.1	6.55	3.40	0.52	1.54	0.97	295
1.2	6.00	3.10	0.52	1.39	0.98	301
1.3	5.60	2.85	0.51	1.30	0.98	305

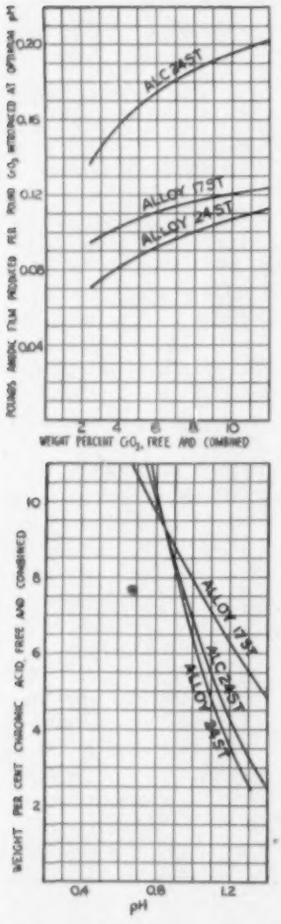

FIGURE 5. OPTIMUM pH FOR DIFFERENT ALLOYS

In chromic acid baths of various concentrations, 30 minutes, 95° F., 40 volts

varied from 0.46 to 0.41 and for alloy 24ST, from 0.47 to 0.35 (Table III).

ALUMINA DISSOLVED. It is apparent that only about half of the oxidized aluminum is retained as anodic film. The remainder goes into solution and its amount is a measure of the rate of deterioration of the bath (*3*). It is the difference between the ordinates of the two lower curves shown in Figures 2, 3, and 4; and, since these curves represent functions of the average current density for a 30-minute period, the alumina dissolved may be expressed as a function of ampere-hours, although it is primarily a function of time, temperature, and composition of the bath. It is shown by the second curve in Figures 2, 3, and 4, as a function of ampere-hours, for the convenience of commercial plants operating with ampere-hour meters. The average for the different alloys and Alclad materials tested was approximately 280 mg. of alumina per ampere-hour at temperatures near 95° F. with baths having a pH in the neighborhood of 0.9. This figure did not change greatly with pH variations —for instance, with Alclad panels for 30 minutes in a 10 per cent bath containing varying amounts of alumina, it was nearly constant at 275 mg. from pH 0.1 to 0.9. Above the latter pH it slowly increased, being 300 mg. at pH 1.2 (Table I). For a 60-minute treatment, normal averages were about 285 mg. (Table II). For alloy 17ST the range was a little wider, being from 255 to 304 mg., but the average was 280 mg.; the range for alloy 24ST was still larger, being from 214 to 321 mg. (Table III). For practical purposes the rate of chromic acid consumption may be estimated by assuming an average of 280 mg. of alumina dissolved for each ampere-hour of operations under ordinary conditions.

EFFECT OF TEMPERATURE. Increasing the temperature greatly increased the current density and the film weight. There was some loss in practical film efficiency resulting from increased rate of solution at the higher temperatures. The effect on film thickness of varying the temperature of the bath from 80° to 110° F. is shown in Figure 6. A special scale is used in this chart based on the relationship between pH and current density. Similar temperature effects were observed for other operating conditions.

THROWING POWER. It was found that the chromic acid bath is capable of almost perfect throwing power. Two small plates were treated 0.5 inch from the cathode, at the same time as two similar plates 27 inches from the same cathode, in a long narrow tank made of a nonconducting material. A new 10 per cent bath with good agitation and accurate temperature control was employed. Voltage was 40, temperature 95° F., and time of treatment 30 minutes. Practically identical current densities and film weights were obtained irrespective of the distances from the cathode. Similar results were obtained for a 60-minute period.

CATHODE SIZE AND TRIVALENT CHROMIUM. Within practical limits the relative size of the cathode with respect to the anode did not affect the weight of the anodic film. Laboratory trials with a cathode having only 2 per cent of the area of the anode produced the same weight anodic film as when the cathode area was increased to approximately 20 times the anode area. A small cathode is desirable in order to avoid accumulation of trivalent chromium. When trivalent chromium was present in a bath, it produced effects similar to an equivalent amount of alumina, except that it was gradually reoxidized to the hexavalent state when a small cathode was used. The color of the anodic film was darker when trivalent chromium was present, but otherwise its character and thickness did not appear to be altered.

TABLE III. ANODIC COATING CHARACTERISTICS

[30 minutes, at maintained pH, 95° F. and 40 volts, in a bath containing 100 grams per liter CrO_3, free and combined (10% bath)]

pH	I Total Alumina Formed, Mg./ Sq. In.	J Anodic Film, Mg./ Sq. In.	L Practical Film Efficiency, J/I	M Current Density, Amp./ Sq. Ft.	N Apparent Electrical Efficiency	P Alumina Dissolved, Mg./ Amp.-Hr.
			For Alloy 17ST			
0.1	3.60	1.60	0.46	2.20	0.75	255
0.2	3.50	1.60	0.46	2.10	0.76	260
0.3	3.35	1.55	0.46	2.00	0.76	259
0.4	3.15	1.45	0.46	1.85	0.78	265
0.5	2.95	1.35	0.46	1.70	0.79	271
0.6	2.65	1.20	0.45	1.50	0.80	278
0.7	2.30	1.05	0.46	1.30	0.81	277
0.8	2.05	0.90	0.44	1.17	0.80	283
0.9	1.90	0.80	0.42	1.10	0.79	288
1.0	1.80	0.75	0.42	1.03	0.80	294
1.1	1.70	0.70	0.41	0.97	0.80	297
1.2	1.65	0.67	0.41	0.93	0.81	304
1.3	1.60	0.65	0.41	0.90	0.81	304
			For Alloy 24ST			
0.1	4.35	2.05	0.47	3.10	0.64	214
0.2	4.20	1.95	0.46	2.95	0.65	220
0.3	3.95	1.80	0.46	2.75	0.65	225
0.4	3.55	1.60	0.45	2.40	0.67	234
0.5	3.15	1.35	0.43	2.10	0.68	247
0.6	2.85	1.20	0.42	1.85	0.70	257
0.7	2.65	1.10	0.42	1.70	0.71	262
0.8	2.45	1.00	0.41	1.55	0.72	269
0.9	2.40	0.95	0.40	1.50	0.73	278
1.0	2.35	0.90	0.38	1.45	0.74	288
1.1	2.30	0.85	0.37	1.40	0.75	298
1.2	2.25	0.80	0.36	1.35	0.76	309
1.3	2.20	0.75	0.34	1.30	0.77	321

MAXIMUM ECONOMY OF CHROMIC ACID. The chromic acid consumption charts (Figure 3) indicate a very definite advantage in treating at about pH 0.85 for 10 per cent baths, and at a little higher pH for 5 per cent baths (Figure 4). The chromic acid consumption was more for the alloys studied than for Alclad products, but the optimum pH was about the same for the alloys and Alclad panels, when using a bath of approximately 10 per cent concentration. A limited amount of work was done at concentrations below 5 per cent and results confirm those calculated from the general anodic coating characteristics—namely, that the point of optimum pH increases with lowering of concentration, and the rate of chromic acid consumption increases (Figure 5, upper). In other words, when treating at the pH of maximum economy, there is less chromic acid con-

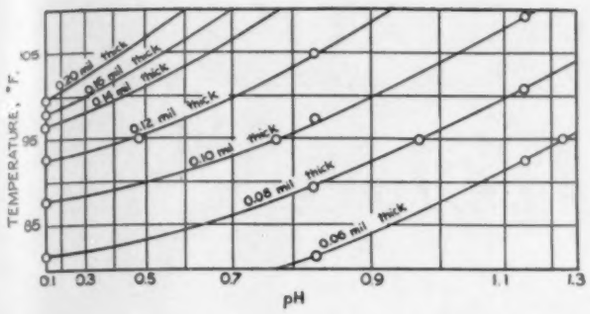

FIGURE 6. EFFECT OF TEMPERATURE AND pH ON FILM THICKNESS

100 grams per liter of CrO_3, free and combined (10 per cent bath), at various pH values with Alclad 24ST, 60 minutes, 40 volts

sumed when using a 10 per cent bath than with a 5 per cent bath. The drag-out is greater with a 10 per cent bath, but this would not affect the chromic acid economy when operating at a maintained pH, because in practice the drag-out would be less than the required draw-off. If thinner films are desired it is more economical to shorten the period of anodic treatment than to increase the pH.

and concentration, or by current density measurements and concentration. This laboratory prefers pH and concentration by analysis. Concentration may also be estimated from the Baumé chart (Figure 7).

THE NEW BATH. When using a new bath nothing need be done except to replace the drag-out and spray loss, until the bath reaches the pH of maximum chromic acid economy. A variation of this method is to begin with a low concentration, say about 2.5 per cent, and when the optimum pH is reached for this concentration, to raise the concentration by the addition of chromic acid without a draw-off. In this manner the bath may be kept at an optimum pH until it reaches a concentration of about 10 per cent chromic acid, free and combined, then maintained at this concentration and pH by small periodic replacements. An advantage of this method is that anodic films obtained while the bath is new approximate those from a used bath operating at an optimum pH. The effect of modifications of the starting procedure, as well as of regular operation, may be calculated from the accompanying data.

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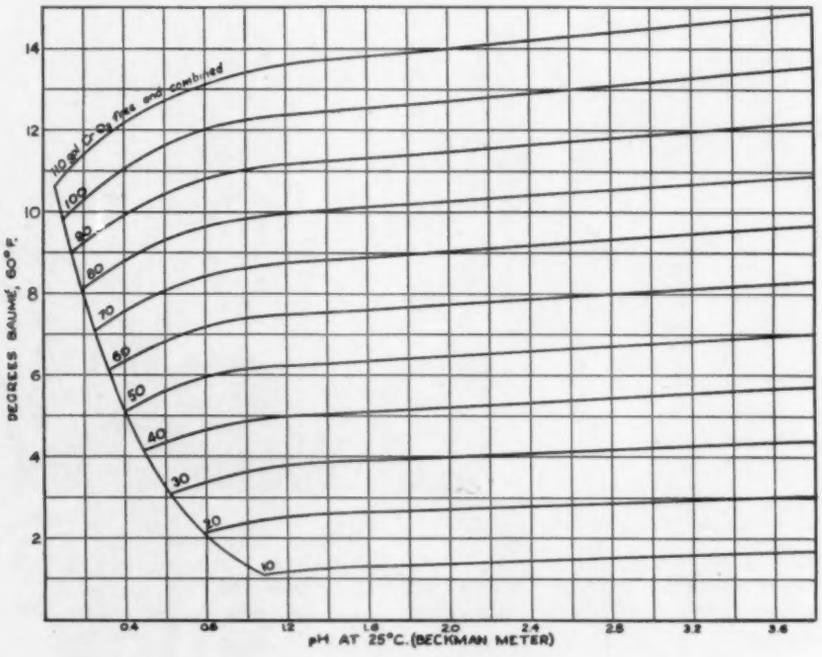

FIGURE 7. BAUME OF CHROMIC ACID BATHS CONTAINING ALUMINA
Relationship of composition, Baumé, and pH

MAINTAINED pH COMPARED WITH BATCH OPERATION. The curves shown in Figure 3 indicate that although the pounds of anodic film produced per pound of chromic acid introduced may be a little greater by the batch method (starting with a new bath and discarding when it no longer produces a satisfactory film), such a procedure actually results in less square feet of satisfactory film than when pH is maintained at an optimum value. In commercial operation the pH may be maintained at the desired point by small periodic draw-offs which are replaced by chromic acid. The proper time and amount of draw-off may be judged by pH

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Sales Appeal of Domestic Appliances Enhanced by Durable and Attractive Finish

FINISHING OF WASHING MACHINES

By Carleton Cleveland

Highland Park, Ill.

TODAY almost every manufactured product must have sales appeal—be attractive as to line and finish—in order to stimulate the desire to possess. Particularly is this true regarding commodities sold to the American homemaker. Modern conveniences have given her more time to acquaint herself (through the advertising pages of newspaper and magazine) with streamline designs and beautiful enduring finishes. Manufacturers of household appliances (among them the makers of washing machines) have recognized this tendency with the result that design, color, and finish are given especial attention.

Along the course of the old Erie Canal, at Syracuse, New York, is the plant of the Easy Washing Machine Corporation. Here, not so long ago, was installed a metal-finishing system for handling the coating of a variety of parts entering into the assembly of the company's line of washing and ironing machines. These parts, passing through the finishing process, consist generally of sheet steel housings and bodies, zinc alloy die castings, and gray iron castings. Since some parts are completely finished before assembly, others but partially, and still others assembled before even receiving a prime coat, it is necessary to tie the finishing operations in with the production process. This has been facilitated by the use of an overhead chain conveyor system, carrying individual parts and sub-assemblies from one department to another and on through the cleaning and finishing processes.

In the finishing process, all parts are passed through a modern degreasing unit, using a standard volatile solvent, vaporized by heat, which removes all oil, grease, and other foreign matter. As the parts—traveling along on the chain conveyor—emerge hot and dry from the degreaser, they pass into a spray Bonderite booth, where they receive a light phosphate coating. Not only does this Bonderizing treatment serve as a rust preventive to the iron and steel surfaces, but it also produces an etched surface promoting maximum adherence of the finishing coats.

Fig. 1. Spindrier washer, attractive in its white porcelain enamel finish and chrome trim.

Priming

Dangling from the chain conveyor, the parts are now ready for priming, some to be dipped and others sprayed. Those parts that lend themselves suitably to the dipping process, are hung on a bar conveyor, the operator wearing gloves to prevent any possibility of leaving finger marks on the clean, rustproofed surfaces. This bar conveyor handles a large proportion of the parts, carrying them through the primer dip tank, and enters an A-shaped oven. Here the speed of the conveyor is so adjusted that ten minutes is required for the passage up to the horizontal arm, during which time the parts are gradually heated to a high baking temperature. Another ten minutes is required for passage through the elevated temperature in the upper horizontal section, followed by ten minutes of travel through the down leg, serving as a cooling zone.

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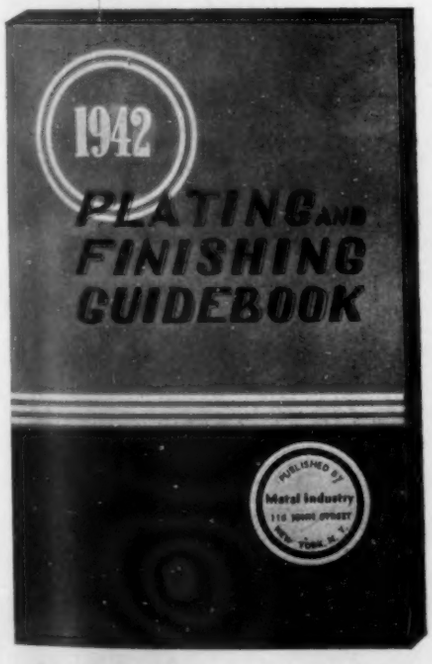

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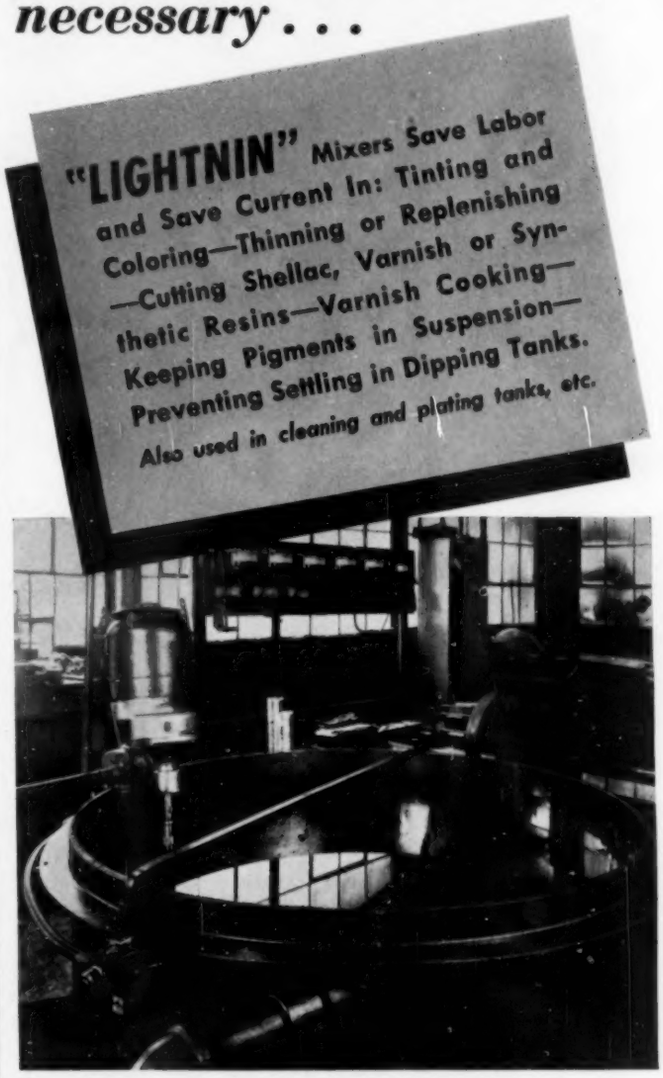
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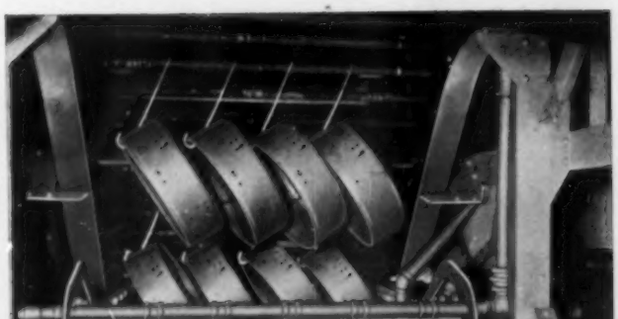


Fig. 2. Parts from production department entering vapor degreaser.

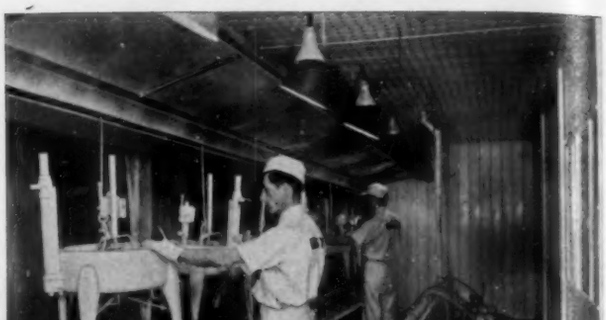


Fig. 3. One of the water-wash spray booths through which the parts pass for the finishing enamel coat.

Further cooling takes place on the chain conveyor, to which the parts coming from the oven are transferred to take them either to the assembly line or to subsequent finishing operations.

There are some parts that do not lend themselves readily to the dipping process, and others requiring a different finish from the dip priming coat. These parts pass directly from the Bonderite treatment to water-wash spray booths, where they receive a priming coat. Here either the regular priming coat or (as in the case of partly hidden mechanical parts) a coat of aluminum paint† may be applied, the paint being brought to the booths in pressure tanks from a central paint mixing rook. A 70-lb. pressure is used on the air applied to the spray lines. As the parts leave these primer spray booths, they pass to a point beyond the dip tank, where they are transferred to the bar conveyor, which carries them through the same baking oven with the machine-dipped parts. Some parts that are hand-dipped are also placed on the bar conveyor at this point and started through the baking oven.

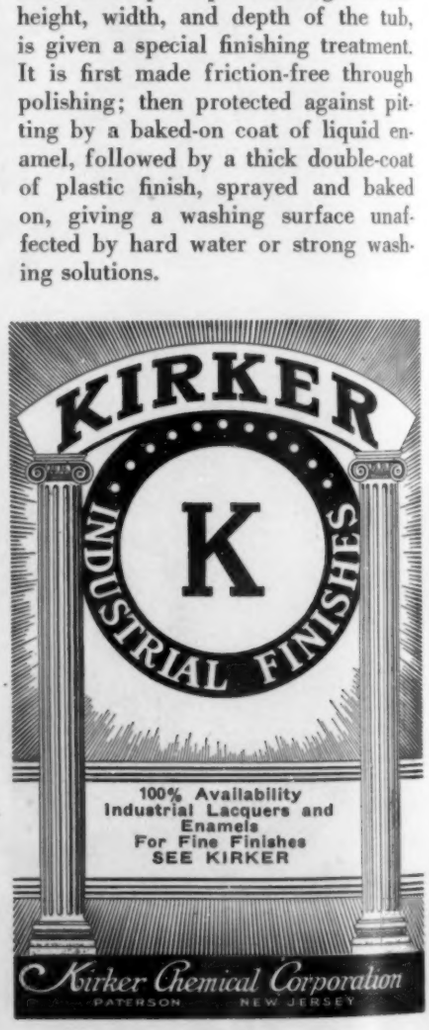
Parts which enter into assembly or other operations following the application of the prime coat are likely to take on finger marks which must be removed before the final finish is applied. This is accomplished by hand wiping with clean cloths wet with solvent and is done as the parts pass along on the chain conveyor just before they enter the spray booth to receive the final finishing coat. This solvent evaporates quickly, and while it is very effective in removing grease and other foreign matter readily seen against the light colored primer, it does not in any way injure the prime coat.

Final Finishing

The final finishing coat of white synthetic enamel is applied in a spray booth of the latest design, one side of which is almost entirely of glass. There are two of these booths, arranged back to back. A temperature of 85° F. is maintained in these booths, the air being washed before entering a booth so as to provide a dust-free atmosphere and healthier working conditions for operators. To maintain the constant temperature within the booths, it is sometimes necessary in severe weather to heat the washed air as it comes through the inlets at the top of each booth. As the work swings along through the booth on the overhead conveyor, each piece receives a fog coat, and after it has partly dried at room temperature, it is sprayed with a final finishing coat. The spray is directed toward a water curtain at the rear of the booth, which catches the excess, washing it down into a trough for subsequent reclaiming. Spray dust and solvent fumes are also drawn off at the bottom, so that operators do not require masks while working in the booth. As the work leaves the spray booth it enters a horizontal baking oven, cooling after emerging as it passes along on the chain conveyor towards the final assembly line.

Finishing Activators

Wringers, washing-machine bases, cabinets, tub covers, and legs are all given the same three layer finish,—rust-proofing of the base metal by the Bonderite chemical process, a baked plastic primer, and a finish coat of pure-white, chip-proof, color-fast, synthetic enamel that perfectly matches the washer tub. The 3-vane aluminum spiralator, producing the uniform water currents which direct each garment in a spiral path throughout the height, width, and depth of the tub, is given a special finishing treatment. It is first made friction-free through polishing; then protected against pitting by a baked-on coat of liquid enamel, followed by a thick double-coat of plastic finish, sprayed and baked on, giving a washing surface unaffected by hard water or strong washing solutions.



†This article was written before the present war and changes in material no doubt have been made.—Ed.

New Equipment

Quick Drying Transparent Coating

Wayne Chemical Products Co., 9440 Copeland St., Detroit, Mich., have announced the development of a new durable, transparent, elastic, quick-drying coating called "Kemi-film".

This coating dries in the air and gives a film with excellent protecting powers, but usually a short bake of 20 minutes at 225° is recommended to obtain a harder film.

Salt spray tests of the coating applied to steel are said to have shown rust resistance for over 90 hours. The coating material is stated to have excellent coverage, dries for handling in from 3 to 5 minutes, and is suitable for all metals, leather, rubber, ceramics, plastics and many other articles.

A pint sample and literature will be furnished by sending $1.00 to Wayne Chemical Products Co.

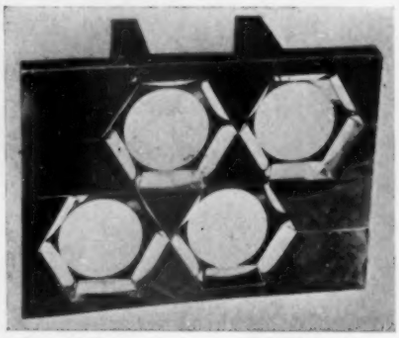
Infra-Red Insulated Reflective Panel

Infra-Red, 1633 E. 40th St., Cleveland, Ohio, have announced the development of infra-red insulated reflective panels available in 10 standard sizes. Dimensions are 8" x 15" x lengths varying from 17" for three lamps to 51" for twelve lamps. The insulated panel is 1½" thick. Finishes available are aluminum, chromium and gold and highly polished chromium on steel is furnished unless otherwise specified.

Some of the features claimed for the new reflective panel are:

Simplification of service wiring; individual toggle switch as standard equipment in rear of each panel makes zone operation easy; high ambient temperatures obtainable using 250 watt lamps.

It is stated that lamp maintenance costs



Front view of insulated reflective panel.

are lower due to elimination of objectionable heat rays that in the past attacked the cement in the lamp bases. The units use 250 watt reflector lamps.

Mixers for Organic Finishing Materials

Because of restrictions on plated finishes, resulting in many companies using paints, lacquers, enamels and other organic finishing materials, the Alsop Engineering Corp., Milldale, Conn., have pointed out that a highly important feature for successful finishing is the thorough and complete mixing of the ingredients. This corporation has supplied mixers to the paint, lacquer and other industries for over 20 years, and are ready to devote their knowledge to the solution of problems in this type of work. The company makes mixers of every kind in portable form, and a newly designed swivel clamp allows positioning of propellers in any vertical or sideways position to get the best possible results.

Complete mixing units composed of both

Complete mixing unit.

the mixer and the container can be provided for various capacities. Tight heads insure against loss of mixture and will keep it in condition for constant use.

A catalog is available showing the company's latest type mixing equipment, and will be sent to those interested.

Cold Water Type Blackout Paints

Tamms Silica Co., 228 N. LaSalle St., Chicago, Ill., have announced the development of two cold water blackout paints, one grade for interior use and the other for exterior use. The interior paint is recommended for coating windows and skylights on the inside, and the exterior grade for the application on the outside of the windows and skylights. It is suggested that for complete blackout purposes, windows be blacked out on both inside and outside.

The paints are furnished in powder form and are quickly and easily prepared for ap-

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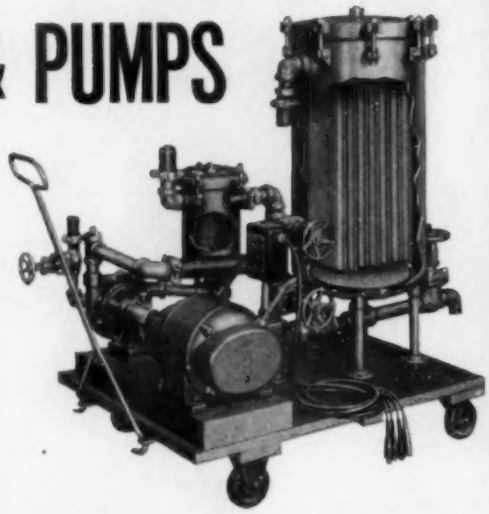

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plication by the simple addition of water. They can be applied by either brush or spray. They produce an intense black, very flat and void of gloss or glare. Five pounds mixed with water are said to cover about 350 sq. ft. of glass surface. Only one coat is needed.

Blackout Paint

A blackout paint has been announced by the Midland Paint & Varnish Co. of Cleveland. This new formula known as "Midland P-40 Blackout Paint" has been made for outside application. The inside painting of glass is not recommended since light reflections and halations would still be visible even for long distances. Reports from aviators indicate that even moonlight reflected from glass, provides guides for bombing raids. The blackout paint dries rapidly (30 to 40 minutes) to a self-leveling, dull, flat surface that inhibits reflections or halations. It can be brushed on or thinned with proper solvent to spraying consistency. Average area covered, 550 sq. ft. to the gallon.

The manufacturers claim that the blackout paint is resistant to heat, unaffected by sun rays, summer heat or high heat from inside buildings, such as heat treating plants, foundries, forges, boiler rooms, etc. Also water or moisture will not affect it. Rain, sleet, snow or exhaust steam will have no effect on the dried paint film.

One of the important advantages claimed for the paint is that it may be easily removed from glass windows simply by wiping off with inexpensive solvent. No special chemicals or expensive scraping are required to put a factory back into daylight operation after danger of destruction has passed.

In the blacking out of a plant with blackout paint on outside of windows, it is also suggested that windows be suitably taped on inside to withstand shattering from bomb concussions.

For further details or samples, write The Midland Paint & Varnish Co., 9110 Reno Ave., Cleveland, Ohio.

Alvey-Ferguson Co. Expand Production Facilities

A 25% increase in production capacity has been the result of the recent completion of the first unit in a big expansion program, according to *John C. Walter*, President of *The Alvey-Ferguson Company*, Cincinnati, Ohio, manufacturers of conveyors and washing machines.

Completed in only four weeks, the new plant is the result of careful preparation and planning, and is modern in every respect, with fluorescent lighting throughout and the latest machinery and testing apparatus for manufacturing and inspection.

New demands for shell and cartridge production, shell loading, gun barrels and other defense items are reported to have caused a heavy demand for especially designed conveying equipment and product washing machines, and The Alvey-Ferguson Company is now preparing a booklet featuring this type of equipment especially for defense work. Those requesting this new booklet are asked to please mention this publication.

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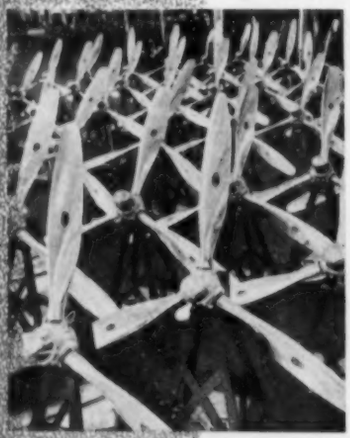

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METAL FINISHING

VOL. 40, NO. 3 PREPARATION, ELECTROPLATING, COATING MARCH, 1942

Restrictions on Plating

THE restrictions on plating and the use of certain base metals, such as tin and lead, have practically eliminated cadmium, chromium and nickel plating for non-war goods. The reductions in copper and zinc plating have also been great.

Cadmium and cadmium containing compounds were restricted drastically on January 17, 1942, by General Preference Orders M-65 and M-65-a. The M-65 Order allows delivery of cadmium only to distributors, those holding Preference Ratings A-10 or higher, and to those accounts specifically authorized by the Director of Priorities. The M-65-a Conservation Order curtails the use of cadmium in a long list of articles that includes almost every non-war item being plated. The order refers to cadmium metal or cadmium salts, and thus plating from cadmium salts using insoluble anodes would also be barred. Certain exceptions to the limitations are made, particularly in the plating of electrical fittings that require cadmium for proper operation and life. The situation on cadmium for general electroplating is bad and will likely get somewhat worse.

The situation in regard to nickel is as bad as for any of the short metals. The deliveries of nickel are made under strict allocation as per General Preference Order No. M-6-a and the holding of even a high priority rating does not necessarily mean that the metal will be available. Order M-6-b issued January 20, 1942, and effective April 1st, 1942, curtails the use of nickel on almost all objects formerly nickel plated. Certain exceptions are made where nickel is necessary for proper operation. Plating with insoluble anodes from nickel salt solutions is also barred. The M-6 Orders and the strict allocation of nickel means that nickel plating, even in the war program, will be largely curtailed.

It should be emphasized that most of the orders restricting the use of metals do not permit anyone to use existing stocks of metals except under the allowances made in the orders.

The situation in regard to chromium and chromium salts is also bad inasmuch as chromium is largely imported from foreign sources. General Preference Order M-18-a placed chromium metal, chromium ores, scrap and chemical compounds containing chromium under very strict allocation. Limitations have not been made on the use of chromium plating, but these limitations are, of course, automatically made by the strict allocation of chromium compounds, and, of course, the decorative plating of chromium has been drastically reduced by the restrictions on nickel plating.

The use of copper has been curtailed by various M-9 Orders and particularly the Conservation Order No. M-9-c amended December 10, 1941. This order curtails the use of copper in a long list of products that composed most of the objects plated. Certain exceptions to the curtailment are given. Exceptions to the limitation on copper plating have been made for the following cases: (1) when the plating of the object on the barred list is not primarily for decorative purposes; (2) when the use of or the normal wear on such item makes impractical any other form of coating, and (3) when the item was formerly plated with copper or copper base alloy, or when the amount of copper used in plating the object is less than 5% of the total amount of copper formerly used in the copper base alloy.

The situation on zinc is less critical than any of the metals already mentioned. To make certain that sufficient zinc is available for all orders, zinc was placed under General Preference Order M-11, the principal feature of which is the assigning of quotas each month which determine how much zinc the producers set aside to cover war requirements. The supplies have been sufficient to cover all war requirements, and some non-war work. No limitations have been placed on zinc plating.

An important order restricting plating indirectly is that curtailing the use of lead, namely, Conservation Order M-38-c. This prohibits the use of lead in many objects, particularly badges, emblems, toys and casket hardware, most of which items were plated or finished in some manner. Lead was not restricted for use as anodes or cathodes in electroplating processes, in baths for the heat treatment of steel and for several other uses. Tin has been restricted and will probably undergo even more drastic restriction.

The metals still available for plating without restrictions or curtailments are: silver, gold, arsenic, indium, palladium and platinum. Rhodium will probably be restricted in the near future because of the present great demands on this metal as an alloy used as a catalyst, and for metal reflectors. Palladium costs about $24 an ounce or about half the price of platinum. It can be plated, but unfortunately, the coating appears to be sensitive to finger stains. Indium offers a possibility for obtaining a white plate, particularly on copper plate and the plating of this metal was discussed in the January issue of *Metal Finishing*. Silver is very plentiful and the present rate of production is almost double that of the consumption of silver. Chemical blackening processes are available for zinc, copper and most copper alloys, and for steel, and there has been a great increase in the use of black finishes, particularly on steel. The use of phosphate coatings has also increased greatly.

Defense Highlights

Assistance for Job Platers

Job platers, machine shops, motor rewinding shops, and other shops performing industrial repairs are eligible for priority assistance under the Production Requirements Plan, or the Modified Production Requirements Plan for small business, it was announced Feb. 5, 1942 by the Division of Industry Operations.

By submitting applications on Form PD-25A or PD-25X, according to the size of their business, companies of these types may obtain a priority rating or ratings to be used over a calendar quarter for specified quantities of material. The rating assigned and the quantity of material it may be used to obtain will depend upon the volume of war or essential civilian work being handled by each company.

Restrictions on the Uses of Lead

Order M-38-c, issued January 10, 1942, provides that after April 1st, lead cannot be used in the manufacture of automobile body solder, as ballast or keels for pleasure boats, as blocks for cutting leather, in building supplies, in caskets and casket hardware, in foil, ornamental glass, regalia, badges and emblems, statuary and art goods, tennis court markers, toys, and as weights for bats, clocks, decoys, dresses, golf club and jockey saddles. Until April 1st, the use of lead for the above mentioned items must be restricted to 50% of the amount used in either the third or fourth quarters of 1941. No restriction is placed upon the use of lead for use in manufacturing plants where corrosion makes lead imperative, such as for plating tanks or for anodes and cathodes used in electroplating processes and baths for the heat treatment of steel. Several other items are included under the list of uses not banned.

Chromium Placed Under Complete Allocation

An amendment to Order M-18-a issued on February 4, 1942, provides that no chromium may be melted except with specific authorization of the Director of Industry Operations. This Order is designed to prevent depletion of existing stocks and to control further the flow of important chromium alloy steels.

Price Control on Titanium Pigments

A price control on titanium pigments has been in effect since March 1st, 1942, under Price Schedule No. 98. This price schedule was issued to avert threatened increases in prices for titanium pigments used extensively in paints, printing inks, rubber compounds and other materials.

Tung Oil Restriction Extended

General Preference Order M-57, which restricts deliveries of tung oil to orders having a preference rating of A-2 or better, or for certain specified uses, has been extended to April 15, 1942. The order was issued on January 8, 1942, and without the extension, which was effective on February 14, would have expired on February 15.

Tungsten Supplies Conserved

Further conservation of tungsten, vital in alloy steel, was ordered February 14, 1942, by J. S. Knowlson, Director of Industry Operations, with issuance of Conservation Order M-29-b. The order prohibits use of tungsten in grinding wheels, gauges and as a coloring material for rubber, linoleum, paper or other similar materials after May 1, 1942. Until that date, use of tungsten in these items is limited to 17½% of the amount used during the year ended June 30, 1941. All other users of tungsten, except those specifically exempted, must reduce their use during March to 12% of the amount used in the year ending June 30, 1941. Such users, after April 1, are limited by calendar quarters to 17½% of the amount used in the base year. Exemptions to the Order include use of tungsten for Army, Navy, Lend-Lease and other Government contracts; to comply with safety regulations; orders bearing preference ratings of A-1-j or higher; corrosion-resisting material; alloy steels; hard-facing materials; hard-cutting tools and tool tips; atomic hydrogen welding rods; laboratory reagents and pharmaceuticals; laboratory research equipment; electrical equipment; radio and x-ray equipment; electronic relays and electric lighting uses, both filament and fluorescent.

Delivery of Finished Copper Products to Ultimate Consumers Not Restricted

WPB recently issued an interpretation of Order M-9-a relating to the deliveries of copper and copper products from warehouses. The interpretation makes clear that the Order applies only to brass and copper warehouses as defined in Order M-9-a and deliveries of completed copper products designed for the ultimate consumer are not included in the prohibitions of the Order.

Saving Tungsten by Using Silver

Tungsten is on the critical list. It's scarce. Silver is more plentiful—and is helping to save tungsten. There is no need, for example, to make high-speed-steel tools entirely of high-speed steel. Only a small tip need have the tungsten-bearing alloy. Practically all the rest can be of carbon steel—thanks to the use of silver brazing alloys for making a secure joint between the two other metals. A joint less than 0.003 in. thick turns the trick, hence little silver is needed and the cost is slight. The same is true in millions of joints brazed with silver alloys or made with silver solders.

Hydrogen Embrittlement†

BY H. J. NOBLE

Chief Metallurgist Jacobs Aircraft Engine Co.

Herein are results of several years of study on methods of determining quantitatively the effect of hydrogen embrittlement as produced by commercial cleaning and plating solutions. Various relief treatments are discussed as well as conclusions drawn from the results of the tests.

THIS paper presents a simple method of determining quantitatively the effect of hydrogen embrittlement as produced by commercial cleaning and plating solutions. And, various curves and data show the effect of heat treatment on the susceptibility to embrittlement on several different steels. Drawing temperature, hardness, section, and chemistry as it affects hardness, are found to be the most important factors. Steels which are subject to a temper brittle range show the highest susceptibility to embrittlement at the range of 500 to 550° F. The embrittlement in steel under 40 Rockwell C is negligible in most cases.

Quantitative data on embrittlement produced by various procedures are given as well as the effectiveness of its relief by thermal treatment. Of the plates investigated, chromium produced the greatest amount of embrittlement and lead the least. For plates of equal thickness, tin is the easiest to relieve and silver the most difficult. Boiling water is the most effective means of relieving embrittlement at that temperature, air is considerably better at higher temperatures, and oil is comparatively poor at any temperature.

Although several investigators have reported the lowering of fatigue strength on standard fatigue specimens due to electroplating, and a diminished workability of sheet in certain forming operations because of pickling, there are no published data, as far as the author is aware, either on the factors that influence this embrittlement phenomenon or simple means of detecting its presence.

These data reported here are an accumulation of occasional tests conducted over a period of several years, during which time the importance of certain factors was appreciated. All of these factors could not be thoroughly investigated, partly because of their multiplicity and partly because they did not involve production problems which, after all, were the underlying reasons for the investigation. Therefore, it is the intent of this paper to present the method of attack on the problem, and the results obtained, with the hope that it may be of some assistance to those having similar difficulties.

The problem of embrittlement first arose after the installation of the Bullard-Dunn process* for descaling after heat treating. A routine check on the crushing strength of tubular shaped pieces as tested between parallels in a testing machine had been instituted as a control of heat treating. When pieces cleaned by the Bullard-Dunn process were tested, less than half the expected value was obtained.

By way of explanation, the Bullard-Dunn process consists of first removing grease in an alkaline cleaner and then subjecting the work as a cathode in a bath containing about 10 per cent sulphuric acid and a very small amount of tin. Hydrogen liberated at the work surface blasts off the scale and as this takes place, a tin film is deposited on the clean surfaces, protecting them from acid attack while the descaling goes on at other points. When the descaling is completed, the entire work surface is covered with a film of tin. The latter protects the work so well that no etching whatever occurs, even when the work is left in the bath longer than is necessary for the descaling. The tin may be left on the work or it may be stripped in an alkaline bath as desired.

It should be pointed out that some investigators have found that embrittlement can be caused by a roughening of the work surface, as for example, by the etching that takes place in pickling; and also by hydrogen absorption. The data given later with respect to the Bullard-Dunn process, then, must reflect the embrittlement caused by hydrogen absorption alone because, as mentioned, etching does not occur when this process is used.

Although some published data state that embrittlement caused by hydrogen absorption cannot be completely removed by baking, subsequent tests proved that it could be, depending on the type of embrittling agent. One hour at 290° F. or ½ hr. at 400° F. in a Homo type furnace completely restored the crushing strength of pieces cleaned by the Bullard-Dunn process to that of uncleaned pieces or those cleaned by sand blasting. The Bullard-Dunn process should not be considered harmful to the most highly stressed parts if given this treatment. However, it must be borne in mind that this relief treatment is not sufficient to remove embrittlement produced in electroplating procedures, as will be discussed.

Testing Procedure

As authorities differ on the treatment for the relief of hydrogen em-

* Covered by foreign and American patents.

† Reprinted from "The Iron Age", New York, Nov. 27, 1941, pp. 45-52.

brittlement, test specimens of heavy walled tubing, 3 in. long, of SAE 6150 steel, were heat treated to about 50 Rockwell C. One-half of the test specimens were cleaned by sand blasting and one-half by the Bullard-Dunn process. The pieces were broken in a testing machine by transverse loading between parallels. The individual values obtained for one series of tests varied considerably, so that the average of at least 10 pieces was used for comparison. The breaking load or crushing strength of the pieces cleaned by the Bullard-Dunn process was only about 35 per cent of that of the pieces cleaned by sand blasting. In other words, there was a 65 per cent loss in crushing strength. Various temperatures for different lengths of time were tried to establish a satisfactory treatment for relief. Both 290° F. for 1 hr. and 400° F. for ½ hr. completely restored the crushing strength of the Bullard-Dunn cleaned pieces to that of the sand blasted pieces. These treatments were adopted as standard as they best suited the existing production set-up.

Effect of Hardness

One of the first factors studied was the effect of hardness. This was accomplished by hardening a large group of tubular test pieces similar to those previously mentioned and drawing them in groups of 20 at various temperatures between 300° F. and 1000° F. at 100° F. intervals. Half of each group was sand blasted and half descaled by the Bullard-Dunn process. The average, the high, and the low crushing strengths for each group were plotted, and the percentage loss was calculated from the average values for each drawing temperature, producing a curve representing the susceptibility to embrittlement. The peak of this curve occurred at 52 to 53 Rockwell C, or approximately at the 550° F. drawing temperature. All subsequent test pieces were quenched and drawn at this temperature of maximum susceptibility.

Embrittlement Relief Treatment

A tabulation of the various relief treatments of pieces cleaned by the Bullard-Dunn process are shown in Table I. As previously stated, the results are the average of 10 test specimens, and for each group heat treated, a group of 10 was set aside and cleaned by sand blasting for comparison. The tin film of the Bullard-Dunn process was left on in these tests.

Further tests were conducted to study the effect of aging at room temperatures both with the tin film left on and removed. Although these tests were not carried out to conclusion, they indicated that for most purposes satisfactory relief might be accomplished in a reasonable time. The tin film tends to retard the rate somewhat. In ordinary manufacturing operations usually enough time has elapsed so that relief is practically complete by the time the piece gets into service. *However, hydrogen embrittlement decidedly increases the susceptibility to grinding cracks in hardened steels.* Where grinding operations follow soon after descaling, it is preferable to use a relief treatment.

The relief of embrittlement produced by the Bullard-Dunn process may be summed up as follows: (1) Relief can be completely accomplished by the proper time and temperature in oil, water or air. (2) Air is better than oil, and water better than air at the same temperature. Air is a better medium at temperatures above boiling water. (3) Aging at room temperature relieves embrittlement. (4) Aging at room temperature is more rapid when the tin plate is removed.

An investigation of the embrittlement effect of cadmium plate followed, using the same type of test piece, heat treatment and testing procedure as in the original tests. The separate groups listed in Table II were heat treated and plated as a group. The plating was done in a production line with no special handling or supervision to make it a laboratory test. The specimens in this case were prepared for plating by cleaning in an alkaline bath and then pickled in muriatic acid for 3 to 5 min. All pieces were plated so as to produce a plate thickness of from 0.0003 to 0.0005 in.

Current densities shown in Table III were such that approximately the same plate thickness was obtained in each case. This was an attempt to determine the cause for variation in per cent of embrittlement in different batches, as is shown in Table II. The initial effect ranged from 30 to 55 per cent loss in crushing strength.

Tests, the results of which are shown in Table IV, indicate that the cleaning cycle is probably the principal reason for the variation in embrittlement from batch to batch. The effect of a bright dip (chrome acid and sulfuric acid types) after plating both on the initial embrittlement and the rate of relief was found to be negligible. One variable on which no quantitative data were obtained is the effect of temperature of the pickle bath. In the regular cleaning procedure, the work may go through either a hot or cold water rinse or both after the hot alkaline cleaner. In any case, the work is fairly warm when put into the acid bath. Depending on the amount of

TABLE I

Bullard-Dunn Process and Its Relief Treatments

Temperature, Deg. F.	*Time*	*Medium*	*Loss in Crushing Strength, Per Cent*
Room	none		65
210	1 hr.	Small oven	30
290	½ hr.	Homo furnace	30
290	1 hr.	Homo furnace	0
350	10 min.	Homo furnace	45
350	½ hr.	Homo furnace	10
400	½ hr.	Homo furnace	0
170 to 180	10 min.	Water	60
170 to 180	½ hr.	Water	55
170 to 180	1 hr.	Water	50
170 to 180	2 hr.	Water	35
212 (boiling)	1 hr.	Water	15
212 (boiling)	2 hr.	Water	0
210	2 hr.	Oil	50 to 55
350	2 hr.	Oil	15
450	2 hr.	Oil	0

TABLE II

Relief Treatments on Cadmium Plate

Temperature, Deg. F.	*Time*	*Medium*	*Loss in Crushing Strength, Per Cent*
Room	none	.....	30
290	1 hr.	Homo furnace	15
400	½ hr.	Homo furnace	15
Room	none	.....	55
400	½ hr.	Homo furnace	45
400	1 hr.	Homo furnace	35
*400	½ hr.	Homo furnace	0
Room	none	.....	35
350	1 hr.	Homo furnace	30
450	1 hr.	Homo furnace	25
550	1 hr.	Homo furnace	25
350	2 hr.	Homo furnace	25
350	4 hr.	Homo furnace	15
350	5 hr.	Homo furnace	10
350	6 hr.	Homo furnace	8
350	7 hr.	Homo furnace	5

* The cadmium plate was stripped from the test pieces in this test and then given the relief treatment to prove that the cadmium plate inhibited the relief.

TABLE III

Variable Effect of Cadmium Plate

Tank	*Plating Conditions*	*Loss in Crushing Strength, Per Cent*
A	Fast plate, 25 min.	40
B	Fast plate, 25 min.	40
A	Slow plate, 40 min.	35
B	Slow plate, 40 min.	30

TABLE IV

Effect of Pickle and Cleaning on Cadmium Plating

	Time, Min.	*Loss in Crushing Strength, Per Cent*
Pickle only, in 50 per cent muriatic acid	0	..
	3	20
	7	25
	15	35
	30	45
Pickle and cleaning	0	10
	3	30
	7	30
	15	35
	30	45

TABLE V

Effect of Aging on Cadmium Plate

Time at Room Temperature, Days	*Loss in Crushing Strength, Per Cent*
½	35
3	30
7	20
14	20

work going through, the acid bath may get appreciably above room temperature, at which temperature the tests in Table IV were conducted. It is well known that the rate of reaction increases rapidly with increased temperature, but probably this increased reaction rate is not compensated for by a corresponding decrease in time in production work.

Table V shows the results of tests made to show the effect of aging on cadmium plate, emphasizing the fact that aging relieves embrittlement.

Other miscellaneous tests conducted along the procedure outlined included tests on the effect of the electrolytic cleaner alone, bonderizing, copper plate, and tin plate, as shown in Table VI. The bonderized test pieces were cleaned in a vapor degreaser while the plated pieces were cleaned in the usual way by an alkaline cleaner and acid dip.

Test Standardization

As materials other than SAE 6150 were being subjected to cleaning and plating, the question arose as to whether the maximum susceptibility to embrittlement occurred at the same hardness in all steels. SAE 52100 was selected because of its high hardness on the quench. As this material was not available in tubing, a machined test piece was used, the dimensions of which were 1⅜" o.d. x 1" i.d. x 1" long. They were just rough machined with a tolerance of plus or minus 0.010" on all dimensions.

A study was then made on this SAE 52100 steel to determine the effect of heat treatment on the susceptibility to embrittlement. As in other tests, the whole batch of specimens was hardened at one time and drawn in lots of 20 at 300, 400, and so on up to 1000° F. From each lot, 10 pieces were cleaned by sand blasting and the remaining 10 were cleaned by the Bullard-Dunn process. This latter method of inducing embrittlement was used again because, in the work done up to that time, it produced the most uniform results. The average crushing load for each group and the individual high and low value were plotted against drawing temperature. The percentage loss in strength was calculated from the average values, producing a curve of embrittlement susceptibility. This is shown in Fig. 1. It will be noticed that the hardness at the point of maximum susceptibility is higher than the first work indicated, about 56 or 57 Rockwell C, but the drawing temperature was the same in both cases.

The coincidence of the drawing temperatures being the same introduced a new possibility. To check this, the same tests were repeated on SAE 1035, the results being shown in Fig. 2.

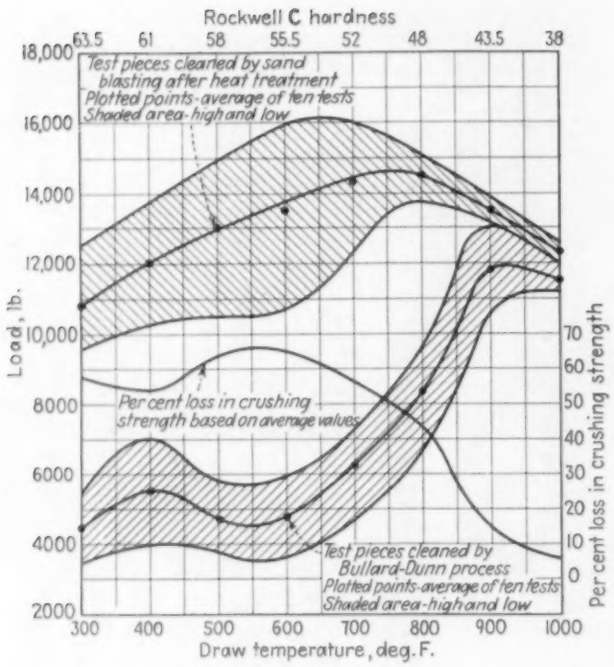
To put the original work on a similar basis, standard size test pieces were machined from SAE 6150 bar stock, the steel used in the original examinations, and these results are shown in Fig. 3. The general characteristics of these curves are quite similar to the original set except that the maximum effect was slightly higher, running over 70 per cent where it had been 65 per cent, and the drawing temperature which produced it was nearer 500° F.

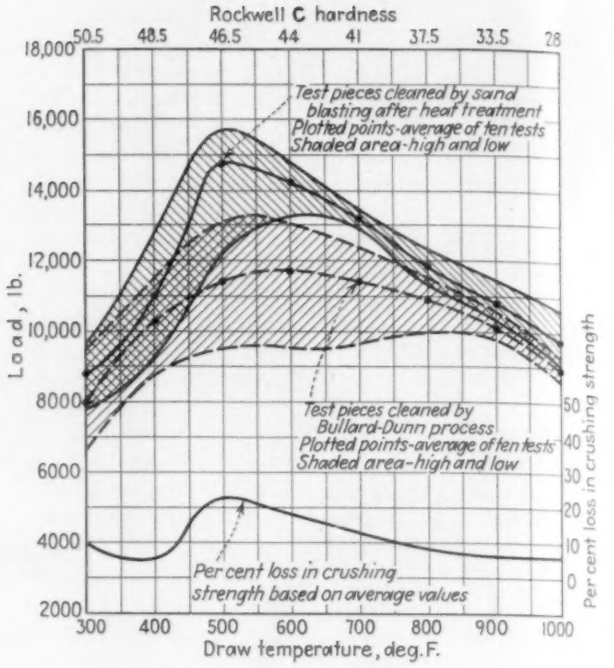
These three sets of curves using the same size test pieces all show that the maximum susceptibility is in the temper brittle range of from 500 to 550° F., and also that hardness is not the controlling factor. One point of further interest was whether a molybdenum bearing steel, supposedly free from a temper brittle range, also had a peak in the same region. Consequently a fourth set of curves was derived from a group of SAE 4640 test

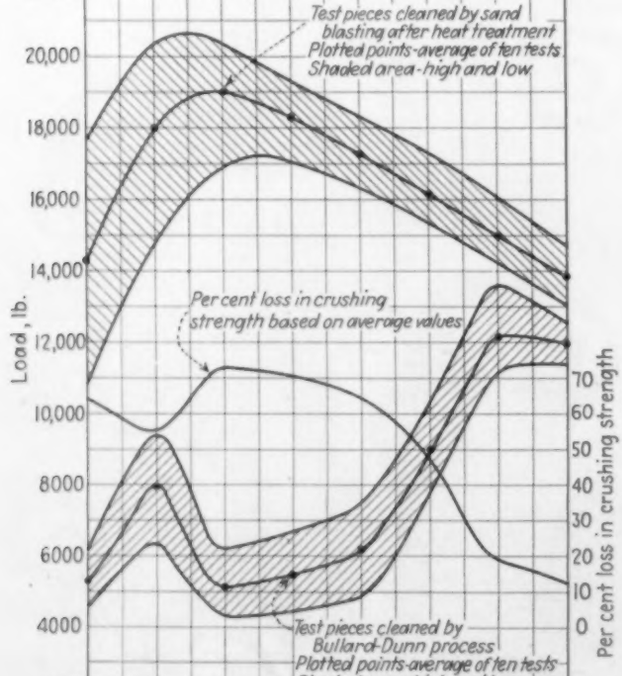
TABLE VI

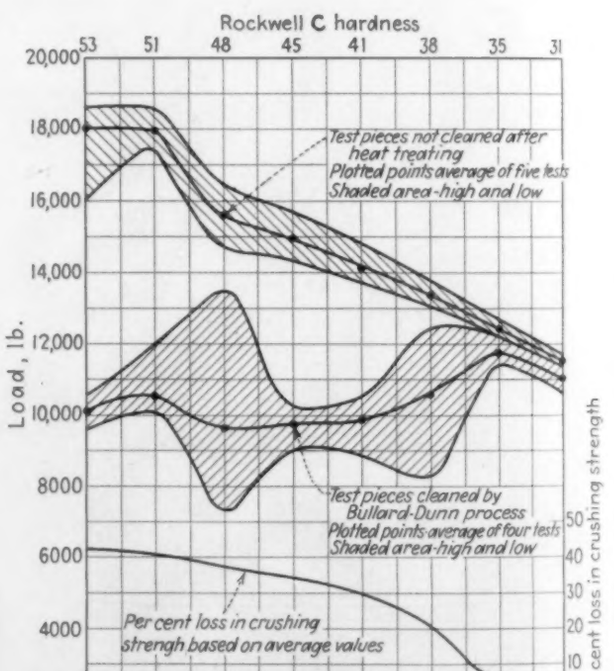
Additional Tests on Embrittling Media

Embrittling Media	*Time Exposed*	*Loss in Crushing Strength, Per Cent*
Hot alkaline cleaner	1 min. anodic 1 min. cathodic	0
Bonderizing	10 min.	3.5
Flash tin plate (alkali stannate)	2 min.	20
Flash tin plate (alkali stannate)	4 min.	40
Tin plate (alkali stannate)	½ hr.	55
Tin plate	1 hr.	55
Flash copper plate	2 to 4 min.	0
Copper plate	½ hr.	30
Copper plate	1 hr.	40


Rockwell C hardness
63.5 61 58 55.5 52 48 43.5 38
Test pieces cleaned by sand blasting after heat treatment
Plotted points-average of ten tests
Shaded area-high and low
Per cent loss in crushing strength based on average values
Test pieces cleaned by Bullard-Dunn process
Plotted points-average of ten tests
Shaded area-high and low
Load, lb.
Per cent loss in crushing strength
Draw temperature, deg. F.


Rockwell C hardness
50.5 48.5 46.5 44 41 37.5 33.5 28
Test pieces cleaned by sand blasting after heat treatment
Plotted points-average of ten tests
Shaded area-high and low
Test pieces cleaned by Bullard-Dunn process
Plotted points-average of ten tests
Shaded area-high and low
Per cent loss in crushing strength based on average values
Load, lb.
Per cent loss in crushing strength
Draw temperature, deg. F.


Rockwell C hardness
58.5 55.5 52.5 50 48 45 41.5 38
Test pieces cleaned by sand blasting after heat treatment
Plotted points-average of ten tests
Shaded area-high and low
Per cent loss in crushing strength based on average values
Test pieces cleaned by Bullard-Dunn process
Plotted points-average of ten tests
Shaded area-high and low
Load, lb.
Per cent loss in crushing strength
Draw temperature, deg. F.


Rockwell C hardness
53 51 48 45 41 38 35 31
Test pieces not cleaned after heat treating
Plotted points average of five tests
Shaded area-high and low
Test pieces cleaned by Bullard-Dunn process
Plotted points-average of four tests
Shaded area-high and low
Per cent loss in crushing strengh based on average values
Load, lb.
Per cent loss in crushing strength
Draw temperature, deg. F.

Figs. 1 to 4. The curves of embrittlement for four different steels, as well as their crushing strengths in transverse loading, are shown in these four graphs. The size of the tubular test pieces used in these investigations was 1⅜ in. o.d. x 1 in. i.d. x 1 in. long. Fig. 1 (upper left). Test pieces of SAE 52100 steel quenched in oil from 1520 deg. F., with 1-hr. draw as indicated in a Homo furnace. Fig. 2 (upper right). Test pieces of SAE 1035 steel quenched in oil from 1550 deg. F., with 1-hr. draw as indicated in a Homo furnace. Fig. 3 (lower left). Quenching in these tests was from 1550 deg. F. in oil, with 1-hr. draw in a Homo furnace. The test pieces were SAE 6150 steel. Fig. 4 (lower right). Test pieces of SAE 4640 steel quenched in oil from 1475 deg. F. and drawn for 1 hr. in a Homo furnace.

Fig. 5. These machined test pieces are SAE 4640 steel, drawn at 400°, 600° and 900° F., after being treated by the Bullard-Dunn process. Test pieces highly embrittled broke into four parts simultaneously and pieces less highly embrittled broke into two parts at the line of contact.

pieces. Sufficient stock for only 72 pieces was available at the time these tests were made so that they were divided, after hardening, into groups of nine for drawing. These were subdivided again into two groups each, one of four which was cleaned by the Bullard-Dunn process and the other of five which was not cleaned at all. The results of the tests are plotted in Fig. 4, and it is readily seen that there is no peak of susceptibility at the 500-550° F. range, but the peak has moved apparently below the 300° F. drawing temperature to possibly that of no draw.

Fig. 5 shows three typical machined test pieces after testing. These were SAE 4640 test pieces representing from left to right 400° F., 600° F. and 900° F. draws, after being treated by the Bullard-Dunn process. Test pieces highly embrittled usually broke in four parts simultaneously. Pieces less highly embrittled broke in two parts at the line of contact. Usually the two cracks occurred very close together, the second crack always at a lower load than the first, and continued application of load would break it further into four parts. Sand blasted or uncleaned pieces even of the highest hardness broke in this manner. Where the embrittlement was low as in the 900° F. draw, considerable distortion took place before cracking.

Additional Plating Tests

As previously stated, most of this work was done over a long period of time and is not presented in the same order that it was completed. Consequently, some of the tests tabulated may seem out of line. For example, quite a few tests were made using unmachined test pieces which later proved to give a lower effect than the standard machined specimens. Also, the effect of analysis was not observed until considerable other work had been done. No attempt has been made to convert these results or repeat them to put them on a common basis.

Table VII shows the embrittling effect of several plating procedures and the effectiveness of relief treatments. All of these results were obtained on machined test pieces, hardened and drawn at 550° F. The chromium and hard nickel plating was done on SAE 52100 test pieces, but the identities of the other test pieces were not recorded in the notes. It will be seen that the plate thicknesses in all cases except one group of silver plated specimens were approximately 0.001". The cleaning treatment used was a standard cathodic alkaline cleaner followed by an acid pickle in every case except for the lead plate, where only an alkali cleaner, with no current, was used.

Tests were conducted to show the effects of copper plating before heat treating, as compared to tests showing the effects on pieces not plated but heat treated at the same time. The plating was of the thickness generally used to prevent carburizing, about 0.0008". Two standard electric furnaces were used, one using precombusted city gas as an atmosphere (A.F.) and the other having no atmospheric control (E.F.). Several important facts were immediately evident from the results of the tests made with copper plating, as shown in Table VIII. When heated to a heat treating or carburizing temperature, copper plating produces a more or less permanent embrittlement which is probably due to the formation of a copper-iron alloy. In the test conducted in the electric furnace with no atmosphere control, most of the copper oxidized and flaked off during the hardening cycle while in the other furnace the copper remained bright. This explains the lower percentage loss in crushing strength of 10 per cent as against 35 per cent. Cyanide stripping bath produces an embrittlement which is readily relieved by heating to 290° F. for 1 hr. This latter point is substantiated in Table IX.

The effect of wall thickness in SAE 1025 tubing was also examined. Tube specimens 1" long with a 2 13/16" o.d. were hardened and drawn at 550° F. The ¼" tube walls were cleaned by sand blasting and had a crushing strength of 28,500 lb. per sq. in., while those specimens cleaned by the Bullard-Dunn process tested at 23,600 lb. per sq. in., a loss in crushing strength of 17 per cent.

Similar tests were made on tube specimens of 2 7/16" o.d., 1 in. long, with ⅜" wall thicknesses. These specimens were hardened and drawn at 550° F. Those cleaned by sand blasting had a crushing strength of 65,600 lb. per sq. in., and those cleaned by Bullard-Dunn process had a crushing strength of 62,000 lb. per sq. in., or a loss in crushing load of 5.5 per cent.

Sand Blasting

Tests were conducted to show that neither sand blasting nor drawing at 290° F. for 1 hr. after heat treating had any effect on embrittlement. The results were rather unexpected but may be explained on the basis that in sand blasting, a work hardening and internal stress effect may be produced, the latter predominating, as sand is more prone to a cutting rather than a peening action. This stress is relieved by the low draw allowing the work hardening effect to predominate. Test pieces were unmachined pieces of SAE 6150 tubing.

A recheck of the results of the tests to show the effects of sand blasting and drawing after heat treating were made on different size stock of the same material.

Treatment	Crushing Load, Lb. per Sq. In. (Average of 30 Test Pieces)
Sand blasted	43,200
Uncleaned	44,100
Sand blasted and drawn at 290° F. for 1 hr.	45,400
Uncleaned and drawn at 290° F. for 1 hr.	43,800

Treatment	Crushing Load, Lb. per Sq. In. (Average of 20 Test Pieces)
Sand blasted	61,000
Uncleaned	61,500
Sand blasted and drawn at 290° F. for 1 hr.	64,600

The results of the first tests made indicate a 4 per cent increase in crushing strength for sand blasted test pieces drawn at 290° F. for 1 hr. Likewise, an increase of 6 per cent resulted from the second examinations.

TABLE VII

Additional Tests on Electrodeposited Plates

Plate	Relief Treatment: Thickness, In.	Temperature, Deg. F	Time, Hr.	Loss in Crushing Strength, Per Cent
Chromium	0.001	none	none	70
	0.001	290	1	45
	0.001	400	1	40
	0.001	400	2	25
	0.001	500	1	0
Hard nickel	0.001	none	none	35 to 40
Silver	0.001	none	none	55
	0.001	400	1	50
	0.001	500	1	45
	0.001	550	2	30
Silver	0.0002	none	none	55
	0.0002	500	1	35
	0.0002	500	1 twice	0
*Silver	0.001	none	none	55
	0.001	400	1	55
	0.001	400	2	50
	0.001	500	2	45
	0.001	550	2	35
	0.001	550	5	30
†Lead	0.001	none	none	0

* Recheck on silver plate. † Cleaning treatment consisted of alkali cleaner only, with no current.

Tests on Flat Spring Steel

Further tests on the embrittlement effect of cleaning and plating solutions were conducted on SAE 1080 flat spring stock. This type of test was suggested by the Wallace Barnes Co., Bristol, Conn., who furnished the test material. The stock was ½" wide x 0.025" thick, hardened and drawn in lead to a hardness of 53 Rockwell C and polished to a bright finish.

The test consisted of placing a 3" piece in a vice end-wise, and closing the vise so that the test piece buckled. The measure of embrittlement was the vise opening at which point the specimen broke. Actually, most of the test pieces were broken on a metallographic mounting press using a hydraulic jack, which procedure allowed for greater accuracy in measuring. All values shown in Tables X and XI are the average results of 10 test pieces, unless otherwise stated.

A very wide variation was found in the embrittling effect of the alkaline cleaner when the flat spring test piece was in the solution 1 min. cathodically and 1 min. anodically. There was no correlation between the effect and pH values (three different cleaners used in different production lines), nor could any set of results be duplicated in the same tank when tried immediately after. At some later date, tests showed that the embrittling effect was produced only when the work was cathodically treated, and there is absolutely no effect when the work is the anode. Typical values are shown in Table XII.

Fig. 6 shows a comparison of treated and untreated flat spring test pieces after breaking. On the left are two springs that were treated cathodically for 2 min. in an alkali cleaner while the other two pieces represent the "as received" condition. The pieces have been placed together to show the amount of permanent set after breaking. In highly embrittled pieces such as that produced by chromium plate, there is no permanent set. The pieces are perfectly straight or flat after breaking.

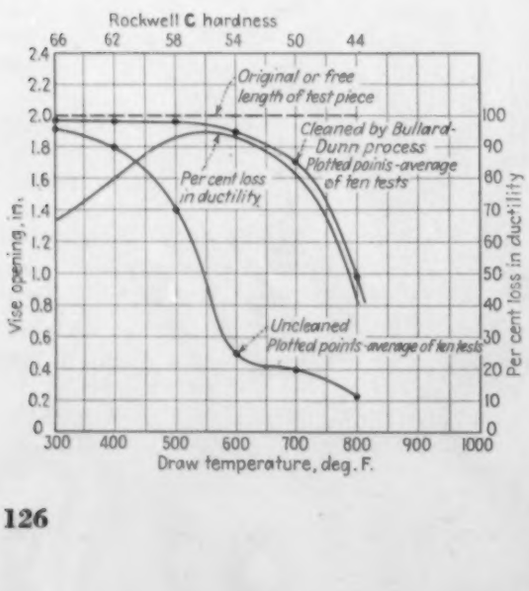


Fig. 7. Results of ductility tests on flat spring steel, tempered and polished, as determined by the measurement of a vise opening when the specimens were buckled to the breaking point. The steel was SAE 1080, quenched from 1450° F. in oil with a 1-hr. draw as indicated in a Homo furnace. The test pieces were 0.025 x 0.50 x 2 in.

Strip Tests and Crushing Tests

An attempt to correlate strip and crushing tests with the original tests was made. Because in the softer tempers a 31-in. piece would not break, a 2-in. length was used. The spring stock, SAE 1080, was annealed and rehardened in an atmosphere furnace at 1550° F. and drawn at 1 hr. at the indicated temperatures. As there was no means of measuring accurately the low pressure required to break the pieces, the vise opening value of embrittlement number was continued. Average values of each group of 10 pieces were plotted for uncleaned pieces and pieces cleaned by the Bullard-Dunn process. A third curve

Fig. 6. The flat spring test pieces at left were treated cathodically for 2 min. in an alkali cleaner, while the pieces on the right were tested before any treatment.

TABLE VIII

Effect of Copper Plate

Furnace	Draw, Temperature, Deg. F.	Copper Strip	Additional Draw, Temperature, Deg. F.	Loss in Crushing Strength, Per Cent
A.F.	550 for 1 hr.	no	none	35
E.F.	550 for 1 hr.	no	none	10
A.F.	550 for 1 hr.	Cyanide bath	none	40
A.F.	550 for 1 hr.	Cyanide bath	290 for 1 hr.	35

TABLE IX

Effect of Cyanide Stripping Bath

Time in Bath, Hr.	Relief Treatment Temperature, Deg. F.	Relief Treatment Time, Hr.	Loss in Crushing Strength, Per Cent
1	none	none	35
3	none	none	45
6	none	none	50
1	290	1	0

TABLE XII

Effect of Alkali Cleaner with Current

Time as Anode	Time as Cathode	Distance Between Vise Jaws, In. Average	High	Low
1 min.	1 min.	1.77	2.12	0.64
1 min.	1 min.	0.73	0.88	0.66
1 min.	1 min.	2.03	2.34	1.88
none	none	0.57	0.60	0.54
2 min.	none	0.57	0.60	0.54
none	2 min.	1.60	1.88	1.32

TABLE X

Effect of Various Plates on Strip Steel

Plate	Thickness, In.	Cleaning	Distance Between Vise Jaws, In. Average	High	Low
None	.....	None (as received)	0.68	0.78	0.62
Cadmium	0.0003	Standard—barrel with regular work	1.63	2.00	1.00
Cadmium	0.0003	Standard—still tank wired separately	2.39	2.40	2.24
Bullard-Dunn process	.....		2.66	2.74	2.54
Bright zinc	?	Pumice only (5 pieces)	2.00	2.29	1.88
Bright zinc	?	Standard	2.42	2.50	2.37
Chromium	0.0005	Standard	2.76	2.78	2.72
Silver	0.001	Standard	2.25	2.50	2.20
Lead	0.001	Pumice only	0.67	0.69	0.64

TABLE XI

Relief Treatment for Bullard-Dunn Process

Temperature Deg. F.	Time	Medium	Distance Between Vise Jaws, In. Average	High	Low
Room	none	Untreated, 20 pieces	0.65	0.76	0.60
180	15 min.	Water	2.51	2.50	2.46
180	30 min.	Water	2.42	2.50	2.32
180	1 hr.	Water	2.33	2.48	2.20
180	2 hr.	Water	1.36	2.04	0.70
290	15 min.	Homo furnace	0.65	0.68	0.58
290	30 min.	Homo furnace	0.66	0.69	0.60
290	45 min.	Homo furnace	0.64	0.70	0.56
290	1 hr.	Homo furnace	0.61	0.66	0.54

showing per cent loss in ductility was calculated from the first two. Results of these investigations are shown in Fig. 7, which discloses an embrittlement susceptibility curve, similar to previous tests, with a well defined peak at 550° F.

Sand blasting shows a permanent effect on the strip test. Since different properties are measured in the two types of test described, no direct comparison can be made, but the tendency is in the same direction.

Treatment	Distance Between Vise Jaws, In.
Untreated stock	0.61
Sand blasted (fine sand)	0.66
Sand blasted (medium sand)	0.71
Sand blasted (medium sand and air drawn 290 deg. F. for 1 hr.)	0.75

It is interesting to note that a period of three years elapsed between the first and last tests. These tests were made on this heat treated strip stock and during that period the untreated pieces showed an increased ductility. The original value was 0.68″ and at different intervals dropped to 0.65, 0.61, and finally to 0.57″. Boiling water treatments and drawing at 290° F. for as much as 2 hr. had no measurable effect on the ductility. No explanation is offered, but it emphasized one point—that frequent checks against a standard are necessary even when dealing with the same heat of material.

Conclusions

(1) Susceptibility to hydrogen embrittlement in general increases with hardness.

(2) Maximum susceptibility to hydrogen embrittlement occurs at the

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Linings for Tanks In the Plating Shop

BY EARL COFFIN

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A FEW years ago most plating tanks were of wood and were lined only to prevent them from leaking or to protect the wood from the corrosive action of the solution. But since the advent of heated, high speed solutions, various other types of tanks have become necessary. In many cases it is necessary for the tank lining to not only protect the tank from the solution but to protect the solution from becoming contaminated by the material from which the tank is made.

In studying the type of tank suitable for each solution in a plating shop I have divided the solutions into three groups: Cleaners, pickling solutions and plating solutions. I have subdivided cleaning solutions into two classes: Alkaline cleaners and degreasers.

Tanks for Cleaners

Alkaline cleaners used either with or without electric current can be operated very satisfactorily in plain steel tanks. Steel is affected very little by the solutions and a steel tank is the easiest type to heat.

I have found that where current is employed, it is better to use a nickel coated steel anode rather than use the tank itself as an anode. Nickel plated anodes do not seem to become coated with a nonconducting coating as readily as do plain steel ones.

This leads me to believe that some of the nickel steel alloys or nickel clad steels might make good cleaner tanks where the tank itself is to be used as an anode. I'll admit that with the nickel situation as it is at present this suggestion is rather pointless.

For degreasers nothing has been found to be better than heavily galvanized steel. Electroplated or hot sprayed zinc coatings are not as satisfactory as hot dipped galvanizing. A plain steel tank is not satisfactory at all. The degreasing solvent attacks it too readily.

For Pickling Solutions

For ordinary cold pickling solutions made with sulphuric or muriatic acid and not highly concentrated, it is quite practical to use unlined wooden tanks made of spruce or yellow pine. It is common practice, however, to line them with asphaltum tank lining, more to prevent leakage at the joints than for any other reason.

For a hot sulphuric acid pickling solution, either lead or rubber makes a good lining. A new type of lining that is gaining a great deal of favor is acid-proof brick. It seems to be an ideal lining for a pickling tank if the treasury will stand the jolt of the initial cost. For small pickling solutions, acid-proof crocks are almost universally used.

Tanks for Plating Solutions

Plating solutions can be readily divided into two groups, acid and alkaline. The most common acid solutions are nickel, acid copper and chromium. For cold nickel solutions, wooden tanks, either unlined or lined with asphalt tank lining, have proved quite satisfactory, and because of their low cost they will probably be used for a long time. But they are only fairly satisfactory for acid-copper and are not at all suitable for bright nickel or chromium. Bright nickel is a case where the solution not only ruins the tank but the tank ruins the solution. Rubber lined steel tanks are used extensively for bright nickel, but I believe that as time goes on, acid proof brick will become more and more popular. Plain steel tanks are not suitable for any nickel solution as all nickel solutions contain chloride of some sort and all chlorides attack steel. Lead has been used for cold nickel solutions but it is not entirely satisfactory. It tends to contaminate the solution.

For acid copper solutions, lead lining is quite satisfactory. Acid copper solutions have been operated in wooden tanks lined with asphalt tank lining, but that is not very satisfactory for if the lining should become cracked or punctured, the tank doesn't last long. Rubber or acid proof brick do very well for acid copper.

Chromium solutions have been operated in unlined steel tanks, but this is not the best practice. Steel dissolves in the solution, eventually ruining both tank and solution. Lead has always been considered standard lining for chromium tanks. The lead is usually strengthened by being alloyed with a small percentage of antimony, tin and/or tellurium. Acid-proof brick has also been found satisfactory. Rubber is entirely unsatisfactory for chromium tanks. However, recent developments seem to indicate that we may some day have a chromium tank lining made from one of the so-called "synthetic rubbers."

The common alkaline plating solutions are cyanide copper, cadmium, silver, gold, zinc, brass and tin. In general, where the pH of a solution is between 8 and 13 and the solution contains no chloride, it can be operated in an unlined steel tank. This is true of cyanide copper, cadmium, zinc, tin and some brass solutions. Some brass solutions contain chloride and this makes steel tanks unsuitable. Silver has a tendency to deposit on steel by immersion, so a silver tank should be lined. Asphalt will do, but it is not the best. Rubber or synthetic rubber is much better. Small solutions of silver and gold are usually kept in porcelain lined tanks. Lead is not good for any cyanide solution. In the vernacular of the plater it "poisons" the solution.

In summarizing, remember that all linings of the same substance are not necessarily the same quality. So when

(*Concluded on page* 137)

Use of Rectifiers for Anodizing

BY JOHN C. BOGLE

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ANODIZING is by no means a new process. For years it has been employed wherever it was desired to produce a hard, dense surface on those aluminum parts which come in for considerable handling or mechanical wear, such as the pistons of internal combustion motors or the inside hardware of street cars.

It is not necessary to go deeply into the chemistry of anodizing in order to understand its application, although there are, no doubt, a number of highly complex salts mingled with the aluminum oxide which predominates in the anodic coating. Aluminum is soft; aluminum oxide is hard. The ordinary thickness of aluminum oxide resulting from normal exposures is inadequate, the oxide itself preventing any considerable accumulation of oxide by blocking off further action of the elements. Such oxidation is of no protection against attrition nor is it sufficiently marked to provide a satisfactory paint or dye base.

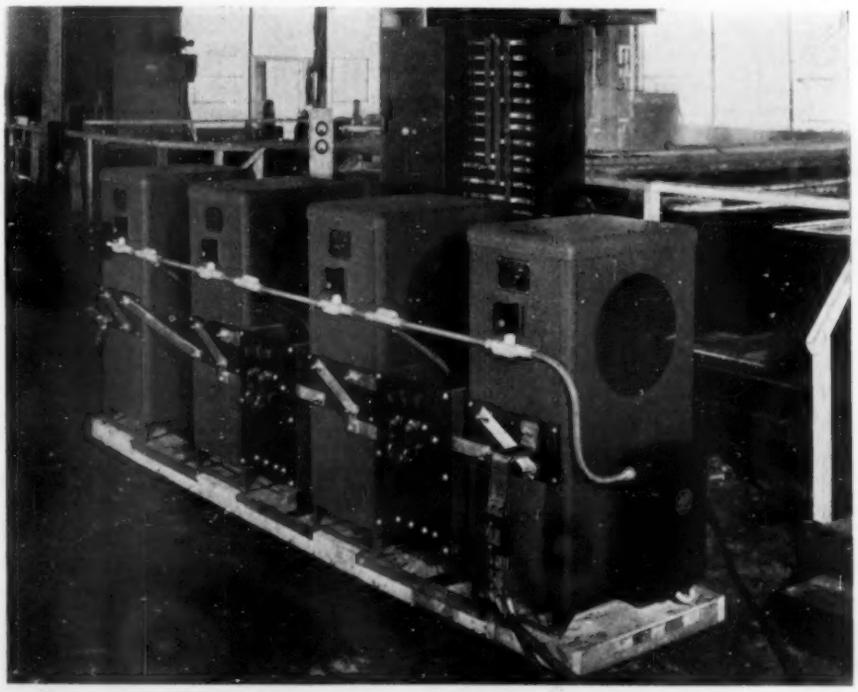
In order to provide a dense, homogeneous oxide layer of sufficient strength-thickness, a peculiar characteristic of aluminum and its alloys is made use of, namely for the oxide film to spread inward when the aluminum piece is held at anodic potential in certain solutions. Whereas aluminum is an excellent conductor of electricity, the oxides of aluminum are fair insulators, not perfect insulators, to be sure, but capable of reducing current flow from the piece to the solution. The process of obtaining and controlling this thicker oxide film by means of direct current and an electrolyte is therefore an art which falls within the boundaries of electroplating practice.

At this point, no doubt, objection might be raised to use of the words "direct current", calling to our attention that anodizing is not restricted to that form of energy, alternating current having been successfully employed for years. However, we should remember that anodizing, not being a reversible process, automatically selects the effective direction of the alternating current to produce the oxide film, a process which amounts substantially to the rectification of an alternating current into what might be called unidirectional or direct current.

And it is odd that a rectifying effect has found widespread application in anodizing, not the approximate rectification to which we have just referred but rather in the use of dry-disk rectifiers for the various anodizing processes that have been developed. Direct-current generators had been used in these processes for over ten years, however the recently realized shortage of power equipment that has followed the unusual stimulation of all phases of the electroplating industry, has invited the application of dry-disk rectifiers in lieu of generators. Incidentally quite interesting and gratifying results have been realized, completely outside those of finding an adequate substitute in an over-vigorous market.

Rectifiers Liquid Assets

One of these "by-product" advantages which have been found to lie in the application of rectifiers to anodizing is the manner in which they maintain investment in electrical equipment as a liquid asset. An assembly of rectifiers sufficient to do satisfactory anodizing is an array of what might



Four rectifiers, temporarily mounted, for chromic acid anodizing, 720 amperes at a maximum of 40 volts.

be called electrical building blocks. The grouped rectifiers thus thrown together in a composite electrical circuit, are capable of being broken down into individual units if it later becomes necessary to use these blocks of power as segregated sources of low-voltage energy in other forms of electroplating.

Every man, woman and child in the World hopes that this war will be of short duration, yet present methods in the building of aircraft may continue for many years. On the other hand, assuming the need for widely separated anodizing plants should, for one cause and another, decrease materially, an anodizing generator would have very little value for other uses in the electroplating field, whereas a group of standard sized rectifiers used for anodizing could be salvaged at a 100 per cent value by the mere process of breaking down the chain into its component blocks of power.

In this connection it should be realized that the more nearly standardized each component power unit can be made, the easier it will be to make the transfer of application when the time for conversion arrives. It is therefore considered wise to apply individual controls such as starters, regulators and disconnect switches to each individual rectifier rather than to groups of rectifiers.

Easy Current Control

Another "by-product" advantage of rectifiers over generators in anodizing practice lies in the ease with which they may be controlled when increasing voltage during the early phase of the anodizing process, at which time the voltage is brought up in a series of increments to the level at which the greater part of the anodizing process transpires.

Starting with an aluminum surface that is practically raw metal, carrying only a microscopic film of oxide which has aggregated from normal exposures, if full voltage were applied immediately it would cause an inordinate current of electricity to flow, much more than the electrical capacity could endure. If, however, the current is first applied at low voltages, the resulting current flow from work to solution can be held under control. With rectifiers, these increments may be promoted by means of an automatic timing system which energizes each component rectifier consecutively leaving the operator free to rack up the next load of work.

Again, it must be understood that the sudden excess current flow just mentioned is of temporary quality, sinking rapidly to a much lower value as the oxide is induced to form, until the amperes reach a datum of steady-state current below which there is no further decrease. We may speak of the transient high current as a "surge," which rises to a peak when the previously formed oxide is punctured by each increasing step of voltage. After the peak of each surge, the current subsides as the oxide film increases in thickness and coverage, quickly reaching the datum of steady-state current as has just been described, whereupon it is possible to increase the voltage in another, still higher step. With each increment of voltage the conditions are repeated until a voltage level is reached at which the specifications call for long-continued application of the steady-state current. The voltage at which this phase of anodizing is intended to take place and the duration of the phase are usually determined by definite specifications.

Types of Anodizing

One of several electrolytes is employed. There is considerable application of a sulphuric acid bath, and any one of a variety of concentrations may be specified. Another type is the chromic acid bath and this also may be specified as one of two or more concentrations. It is not readily apparent just what difference may be expected between these various concentrations either in technique or results. No doubt we shall learn more when the specifications of today are viewed more critically in the future. Right now we are engaged in getting out production, still we should hold ourselves in readiness for changes in specifications as we learn more about the effect of anodizing in its resistance to corrosion and attrition effects.

Although anodizing is proceeding apace with gratifying success when accredited specifications are followed, nevertheless no *final answers* have been found to the problem of providing anodizing equipment for all the alloys and for all the purposes which the process is intended to serve and for all the solutions thus far proposed. It has been learned that the sulphuric process can be improved by operation at a bath temperature of 70° F. or less, thus producing a denser coating, one with less instances of sponginess. In comparing one product with another, the final measure of effectiveness is the salt spray test, and there is reason to believe that this method is itself not altogether indicative of the performance of anodized surfaces under all sorts of exposures amplified with all sorts of subsequently applied coatings.

A great deal is being learned by test and experience under actual operating conditions and this, of course, will eventually emerge into practice and the writing of new specifications for equipment. Where these researches will lead us is, frankly, beyond the knowledge or guess of this correspondent. It is even possible that anodizing may be supplanted entirely by newly developed processes. If the reader will permit an expression of ignorance in what is at least an approach to a technical article, our thesis is that we are gaining experience rapidly, we have good methods specified, we shall probably improve them and finally if and when such improvements come they may bring new specifications covering the equipment, the voltages, the temperatures, etc., of the amended processes. Equipment should be chosen which is sufficiently flexible, sufficiently adjustable, so that it can meet the new techniques without replacement or, in the last analysis, the equipment should be convertible to other uses. To this writer, at least, these facts stand forth as a telling argument for the preselection of rectifiers rather than generators for the anodizing processes.

For example, consider the effect of lowering the bath temperature of the sulphuric acid process in order to reduce sponginess of the anodic coat. Solutions being of negative temperature coefficient, the temperature reduction lowered the current previously available at voltages of 12 and 18. This effect was compensated by recourse to higher voltages. The specification for equipment today is usually set at 24 volts for sulphuric anodizing at the low temperatures now employed. At one time there was considerable chromic acid anodizing at 50 volts. Now anodizing in chromic solutions is nearly all performed at 40 volts, at least all work done under

(*Concluded on page* 135)

Cadmium "Food Poisoning"*

SAMUEL FRANT,† M.D. AND IRVING KLEEMAN‡

IN recent years cases of gastroenteritis in groups, designated for want of a better term as food poisoning, have been much more thoroughly investigated, and as a result the distinctive characteristics peculiar to various individual etiologic factors have been more clearly defined. For example, the description of the symptoms of staphylococcic food poisoning almost invariably follows a definite pattern, and as a result the experienced investigator often suspects the condition long before the final confirmatory bacteriologic report is completed.

A similar situation exists in the case of acute poisoning with cadmium, a characteristic type of gastritis caused by the accidental contamination of certain food and drink with soluble cadmium compounds. In our experience the history of the preparation of the food or drink and the clinical pictures are so similar in all outbreaks that the diagnosis is evident once the condition is thought of and the pertinent facts have been ascertained. The following four outbreaks occurring in New York during the past three years and definitely traced to poisoning with cadmium are illustrative of this syndrome. There is little doubt in our minds that other outbreaks have occurred but have not been brought to the attention of the department of health.

Report of Four Outbreaks

FIRST OUTBREAK.[1]—On June 15, 1937 at 1:15 p. m., 3 members of a family, 1 adult and 2 children, drank cold "lemonade" made from a flavored, yellow crystalline powder. Fifteen minutes later all 3 became ill with nausea, abdominal pains and vomiting. Three other members of the family who had eaten the same food as the first three but did not drink the "lemonade" remained well. The patients recovered completely within twenty-four hours.

The colored powder was essentially a mixture of tartaric acid, sugar, lemon flavor and a certified coal tar dye. Chemical examination of the "lemonade" and of the flavored crystals from which it had been made showed 0.3 mg. of cadmium present in the liquid per gram (300 parts per million) but no cadmium in the original concentrated crystals. It was determined that the drink had been made by dissolving the crystals with tap water in a glass bowl. This mixture was stirred with a wooden spoon and poured for cooling into one of the ice cube trays of an electric refrigerator. The tray and divider on examination were found to be cadmium plated. This refrigerator had been used by the family for twelve years but had never before been utilized for the purpose of cooling an acid mixture. How the tray became cadmium plated could not be determined; the manufacturer, one of the largest in the industry, stated that cadmium never had been used as a plating material.

SECOND OUTBREAK.—On June 29, 1938 7 persons, 5 adults and 2 children, members of three separate neighboring families, became ill within half an hour of drinking home made punch. They had consumed no other food or drink in common. The symptoms were nausea, abdominal cramps and weakness.

The drink had been prepared from a fruit-flavored punch syrup, the juice of two lemons and two oranges and tap water. To cool the mixture, ice cubes taken from a metal refrigerator tray of the electric ice box in the home were placed in the punch, which stood in a glass pitcher.

In the routine investigation, the following samples were examined: prepared punch, ice cubes, fruit syrup, tap water, the spoon and the refrigerator tray. Cadmium was found present in the prepared punch, 0.067 mg. per gram (67 parts per million); in the ice cubes, 19 and 8 parts per million (two separate samples), and in the plating of the refrigerator tray, which was found to be coated with the metal cadmium. No cadmium was found in the syrup concentrate or in the tap water taken from the home.

Questioning disclosed that on the afternoon of the day in question there had been a leak of the refrigerant, sulfur dioxide. After the leak had been repaired, the water in the tray had been replaced with fresh water, which was then frozen into the ice cubes used in cooling the punch. The sulfur dioxide dissolved in the water to give sulfurous acid, which reacted with the cadmium to give cadmium sulfite. It was also determined that the electric refrigerator had been bought at second hand, but we could not trace where and under what circumstances the replating of the ice cube trays with cadmium had occurred. In this instance too the manufacturer stated that the trays originally had contained no cadmium, aluminum being the only metal used.

THIRD OUTBREAK.—On Jan. 7, 1940 5 persons in one family, 2 adults and 3 children, became ill after a dinner served at about 1:30 p. m. Within fifteen minutes several members were attacked with nausea, abdominal cramps, vomiting and diarrhea, and within one hour all were similarly affected.

Suspicion was immediately directed to the dessert, a raspberry gelatin mixture. This had been prepared the same morning by mixing the contents of a ¾ ounce (21.2 g.) package of a widely distributed gelatin powder with 2 cups of boiling water, permitting the

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From the City of New York Department of Health.

† Mr. Kleeman is now instructor in food science at the Food Trades Vocational High School.

‡ Jerome B. Trichter, director, and Herman Erde, assistant director, and the inspectorial and chemical forces of the Bureau of Food and Drugs of the department of health made the investigations and analyses of the outbreaks described.

1. Pensa, A. J.: "An Unusual Case of Food Poisoning," Food Inspector **4:** 5 (March) 1938.

mixture to cool and then transferring it to a metal ice tray in the electric refrigerator. The congealed mixture remained in the tray for three hours before it was served. The original gelatin powder contained added citric and tartaric acids.

A sample of the remaining gelatin dessert was reported as containing 0.53 mg. per gram (530 parts per million) of cadmium. The metal freezing tray was found to be cadmium plated. The refrigerator in this case had also been purchased at second hand about three years previously, and the manufacturing company disclaimed equipping it when new with cadmium-plated trays. It was impossible to trace the reconditioner and so determine under what circumstances the trays had been cadmium plated.

FOURTH OUTBREAK.—On July 11, 1940 6 persons, 2 members of a family and their 4 guests, 2 adults and 4 children, became ill with vomiting and cramps within ten minutes after drinking iced tea. The guests had not previously had any food or drink in common with the family.

The tea was prepared as follows: The juice of three lemons was squeezed into a metal pitcher, boiling water was then added and tea balls were steeped in the solution. The mixture was allowed to cool in the pitcher for one hour before ice cubes were added. A sample of the iced tea was found to contain 0.16 mg. per gram (160 parts per million) of cadmium. The freezing tray in this case was found to be free from cadmium, but the metal pitcher used in the preparation of the tea was discovered to be plated on the inside with cadmium. Although this pitcher had been in the family for eight years, at no previous time had it ever been used for any acid drink. The pitcher was traced by means of its identification stamp to a local manufacturer, who, however, denied ever using cadmium as a plating metal. Similar sample pitchers taken from his plant did not contain cadmium.

In addition to these four outbreaks, the records[2] of the department of health contain details of the illness of at least 29 school children in three boroughs of the city who were reported as having violent nausea during the first week of May 1929. After five or six hours all the children recovered completely. In the investigation of these illnesses a history was obtained from the children that popsicles (flavored ices frozen on a stick) had been eaten just previously to the children's becoming ill. Samples of the popsicles were collected and examined in the chemical laboratory of the department. They were found to contain between 0.013 and 0.015 mg. per gram (13 to 15 parts per million) of cadmium. Further investigation indicated a common source for the popsicles, and complete studies were therefore made at the manufacturing plant. The popsicle mixture, containing fruit acids, coloring material, sugar and water, was found to be free from cadmium before freezing, and only in the finished product after its removal from the molds did the cadmium appear. Examination of the popsicle molds themselves revealed them to be plated with cadmium. Further investigation disclosed that the molds in question had been lent by the manufacturer to another popsicle plant and that before their return the surface of the molds had been found to be so worn that they had been replated, cadmium being used as the replating metal.

The molds and all the finished food products in the plant were seized, and no further operations were permitted with any cadmium-plated molds.

The Syndrome

There have thus come to our attention five outbreaks involving at least 50 persons attacked with a similar complaint. This appears as violent, acute gastritis which occurs almost immediately after ingestion of a liquid or a readily dissolved solid of acid nature containing a soluble cadmium compound. It apparently attacks everybody who partakes of the contaminated food, in contrast to those types of bacterial food poisoning due to salmonella or toxic filtrates formed by organisms such as staphylococci in which some persons are affected at varying intervals of time while others may escape the illness completely.

Acute poisoning with cadmium is similar to acute poisoning with soluble compounds of zinc, and while there were no fatalities in our cases or in any in the literature reported as due to the ingestion of cadmium compounds, there are several instances in which exposure by inhalation to cadmium fumes in industrial activities has resulted fatally. Autopsy in 1 such case reported by Legge[3] revealed congestion of the respiratory and intestinal tracts, fatty infiltration of the heart and liver, hemorrhagic inflammation of the spleen and acute inflammation of the kidneys.

Chronic poisoning due to continued ingestion of minute amounts of cadmium compounds has never been reported, nor is there any great likelihood that such a condition is at all prevalent, since the immediate, violent, emetic action results in the elimination of most of the poison. In industry, however, with constant exposure by inhalation, cases of chronic poisoning have been recorded in which the symptoms were digestive disturbances, loss of appetite, vomiting and cachexia.

The experimental evidence for the development of chronic poisoning with cadmium in animals is at present incomplete, several investigators finding no true storage of the metal in the tissues of experimental animals, while others hold that this may occur.[4]

Chemical Aspects

Cadmium is a ductile metal of bluish white appearance with an atomic weight of 112.41 and a melting point of 320.9° C. It is capable of taking a high polish; on this is based its rapid rise in industry as a plating metal for rustproofing. It was first used as a coating for strings on pianos and other musical instruments, but now it has been adopted as a coating for many motor vehicle parts because of its relatively high melting point and resistance to wear.

Cadmium is insoluble in water and closely resembles zinc in its chemical reactions, being nearly always found associated with zinc ores in relatively small quantities. In these ores cadmium is present, together with zinc sulfide, zinc carbonate and zinc silicate, as cadmium sulfate, cadmium carbonate and cadmium silicate. The cadmium content of zinc ores varies generally from 0.1 to 0.5 per cent; occasionally some ores are found which contain from 2 to 5 per cent. The pure metal is obtained as a by-product in the distillation of zinc. When cadmium is heated in air it burns readily, evolving brown fumes of cadmium oxide. The most important compounds

2. Miller, R., and MacNeil, R. L.: Personal communications to the authors.

3. Legge, T. M.: Cadmium Poisoning, in Annual Report of Chief Inspector of Factories for 1923, London, His Majesty's Stationery Office, 1924, p. 74; cited by Prodan.[4]

4. Prodan, L.: "Cadmium Poisoning: I. The History of Cadmium Poisoning and Uses of Cadmium," J. Indust. Hyg. **14**: 132 (April) 1932.

of cadmium are the oxide, sulfate, sulfide, chloride, iodide and bromide.

The importance of cadmium from the medical standpoint derives from its solubility in acids. The cadmium metallic coating on utensils used for food dissolves when in contact with solutions containing as little as 0.5 to 2.5 per cent of acetic acid. Cadmium is also soluble in other organic acids commonly found in foods, such as citric, tartaric, malic and lactic acids, even though the concentrations of these may be small. With all these, organic cadmium salts are formed. These salts, when taken internally, combine with the hydrochloric acid of the gastric juice to produce poisonous cadmium chloride.

Cadmium is readily detected in food or vomitus. The wet ash solution should be neutralized and made slightly acid, and then hydrogen sulfide should be passed in. Yellow cadmium sulfide is precipitated.[5]

Toxicology

Cadmium presents its greatest hazard to the health of man during its production and in the handling of its compounds. Most dangerous are the inhalation of fumes and vapors arising from retorts or condensers while cadmium and cadmium oxide are being manufactured and the inhalation of dust in bagging and handling the materials.

The syndrome arising from the ingestion of cadmium compounds was studied in animals by Schwartze and Alsberg in 1923.[6] They fed cats cadmium chloride in raw, hashed, lean meat, in fish juice and in meat extract. It was more toxic in dilute solutions than in concentrated solutions. The consumption of an average-sized meal of raw, hashed meat containing 350 to 400 parts per million of cadmium was almost always followed by emesis. In experiments on continued feeding, concentrations of 250 or more parts per million were fatal; there was no evidence of cumulative systemic action. There was no storage other than in the kidneys, the liver and the spleen.

Schwarz and Otto[7] fed cadmium carbonate to cats in amounts varying from 1 mg. to 11 mg. per kilogram of body weight for periods of two months. These animals showed more or less pronounced loss of weight, sometimes followed by death. Some showed a decrease of from 10 to 20 per cent in the hemoglobin content, a decrease in the red cell count and an increase in the number of leukocytes, especially the polymorphonuclear leukocytes.

Prodan[8] in 1932 investigated the pathologic changes observed microscopically in poisoning by food and also determined the distribution of cadmium in the body. The poisoning was produced by feeding cats cadmium carbonate and cadmium phosphate. No difference was noted in the action of the two salts. Cadmium fed in large doses (200 mg.) induced vomiting with salivation and loss of appetite. Vomiting also occurred for a short period following medium (10 mg.) doses but was absent after small doses (2 mg.) The vomiting and the loss of appetite were followed by loss of body weight.

Prodan found further that, irrespective of the dose of cadmium fed, the liver and kidneys were affected. The liver was found to reveal changes varying from general granulation of the cells to pronounced fatty infiltration, especially around the central vein. The kidneys showed a fatty infiltration which was more prominent in the convoluted tubules. Cadmium was retained in the liver in greater absolute quantity and in the kidneys in greater relative quantity. The bones also retained a high percentage. Cadmium was excreted slowly through the kidneys and the gastrointestinal tract. No definite changes were found in the blood.

Previous Outbreaks

There is little in the literature concerning poisoning by the ingestion of cadmium and its compounds. The first reported cases of cadmium poisoning from oral ingestion in human beings were noted by Wheeler[9] in 1876. In his 2 cases, cadmium bromide had been taken orally for medicinal purposes instead of ammonium bromide, the bottle having been wrongly labeled at the factory. In these cases the symptoms were an extremely pungent taste, severe vomiting, complaint of a burning sensation in the stomach and diarrhea. The vomiting and diarrhea lasted fully five hours, during part of which the pulse was imperceptible. The quantity taken was not estimated.

It was not until 1928, some fifty years later, that further mention was made of poisoning from the ingestion of cadmium. An outbreak of illness apparently caused by cadmium-plated utensils was reported by the Los Angeles station of the United States Department of Agriculture in November 1928.[10] In this outbreak a manufacturer of fruit juice products delivered three 5 gallon (19 liter) cans of a combination of fruit juices to a fraternity house, a grade school and a city high school. A number of persons became sick with nausea and diarrhea almost immediately after they had partaken of the beverage. The city chemist secured samples of the product. Analyses indicated the presence of cadmium salts in fairly large amounts. Investigation at the plant showed that the manufacturer, in search of a container that would not corrode, had had the cans for the fruit juice products plated with cadmium by a local concern. These cans showed streaks of corrosion on examination. They were said to have been used only a few times previous to the outbreak.

In 1934 C. R. Hazen[11] reported the illnesses of 3 women who ate a gelatin mixture. The circumstances surrounding these cases were almost exactly similar to those in outbreak 3 of our series. Two ladies had made a dessert with a lemon gelatin dessert powder and poured it into an ice cube pan in their apartment refrigerator to obtain a firm, cold jelly. They ate part of this dessert during the evening meal. In a short time both became ill. Violent vomiting followed by diarrhea of a watery character and dryness of the mouth and throat were the most noticeable symptoms. The remainder of the jelly was left in the pan until the next day. By this time the two ladies had recovered. Meanwhile, not suspecting the jelly, they gave some to their charwoman for her lunch. She, too, became violently ill, manifesting the same symptoms, and was sick for a week. It was then that the jelly was

5. Jacobs, M. B.: "The Chemical Analysis of Food and Food Products," New York, D. Van Nostrand Company, Inc., 1938, p. 141.

6. Schwartze, E. W., and Alsberg, C. L.: "Studies on the Pharmacology of Cadmium and Zinc with Particular Reference to Emesis," J. Pharmacol. & Exper. Therap. **21:** 1 (Feb.) 1923.

7. Schwarz, L., and Otto, A.: "Is Cadmium an Industrial Poison?" Ztschr. f. Hyg u. Infektionskr. **104:** 364, 1925.

8. Prodan, L.: "Cadmium Poisoning: II. Experimental Cadmium Poisoning," J. Indust. Hyg. **14:** 174 (May) 1932.

9. Wheeler, G. A.: "A Case of Poisoning by Bromide of Cadmium," Boston M. & S. J. **95:** 434 (Oct. 12) 1876.

10. Food, Drug & Insecticide Rev. **12:** 26 (Nov.) 1928.

11. Hazen, C. R.: "Cadmium is Poisonous," Food Industries **6:** 268 (June) 1934.

suspected and the trays in which the jelly had been set were taken to an analyst. The coating on the trays was found to consist of a metallic alloy containing more than 50 per cent cadmium.

The only other references relating to the ingestion of cadmium are two abstracts of papers not available, one by Griebel and Weiss[12] and the other by Larsson.[13] In the first of these a typical case of cadmium poisoning is reported caused by ingestion of coffee prepared in a factory. The kettle in which the coffee was brewed had previously been treated with hydrochloric acid containing a cadmium salt. Some of the cadmium had remained in the kettle.

In the other, several persons in Sweden were reported to have had serious symptoms of poisoning after eating food prepared in a cast iron roasting pan. Examination showed a white coating of cadmium on the pan. This type of pan had been manufactured from ordinary cast iron and electrolytically plated with cadmium.

Comment

The importance of recognition of the syndrome which has been described is of course manifest. Any way by which the various types of food poisoning may be subdivided so that the responsible agent may be readily and quickly ascertained is of great value, since prevention of further spread is thereby attained. In the case of acute poisoning with cadmium, knowledge of the preivous history of the syndrome will enable the wide awake investigator to spot the similarity between the outbreak he may be investigating and those herein described. It is obvious that once attention is called to the possibility of acute poisoning with cadmium it can readily be detected almost from a mere description of the type of outbreak.

A far more important result of the knowledge that acute poisoning with cadmium compounds can occur, and in fact does occur, is the necessity for taking definite steps toward the prevention of further outbreaks. These should be as follows:

1. No utensils to be used in the preparation or dispensing of food or drink should be permitted to be plated with cadmium. In every basic state and municipal public health law relating to the manufacture and preparation of food there should be a provision for this control. In addition, in order to provide full protection throughout the country, there should be federal regulations prohibiting this practice in interstate commerce.

2. Health officers and manufacturers of utensils for food should be made cognizant of the syndrome of poisoning with cadmium and the necessity for restricting the use of this material. It is especially important today that the plating industry, searching for substitues for tin and other valuable war materials, be cautioned that cadmium is not a suitable substitute in the plating of utensils for food. New York City has already taken these steps. The plating industry was called into conference and advised to discontinue the use of cadmium in utensils and dispensers for food. Subsequently, the sanitary code, which deals with all measures concerning the health of the citizens of the city, was amended to prohibit the use of cadmium in articles used in the preparation of food and drink.[14]

Summary

In the five outbreaks of acute poisoning with cadmium here reported, involving approximately 50 persons, the syndrome was characterized by violent acute gastritis occurring almost immediately after the ingestion of the contaminated food. A typical outbreak may be detected with ease if the characteristics of the syndrome are kept clearly in mind. The association of immediate food poisoning of groups with the ingestion of an acid liquid prepared in a metal container should cause suspicion, and an immediate investigation for the presence of cadmium-plated utensils should be made.

12. Griebel, C., and Weiss, F.: "Intoxication by Cadmium-Containing Coffee," Pharm. Zentralhalle **72**: 689, 1931; abstracted, Chem. Abstr. **26**: 1659 (March 20) 1932.
13. Larsson, R.: "A Case of Cadmium Poisoning of Human Beings," Samml. Vergftngsfall. **7**: 33 (part A), 1936; abstracted, Chem. Abstr. **31**: 7535 (Oct. 20) 1937.
14. Sanitary Code, City of New York, Sect. 145.

Illnesses Traced To Cadmium Food Containers

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DIVERSION of such substances as aluminum and stainless steel to the war industries has resulted in the use of substitutes for these materials in several types of food containers. Because cadmium is a very satisfactory substitute insofar as the quality of material is concerned, it has been used for the plating of new equipment and the replating of old. The toxicity of this material has resulted in a number of food-poisoning outbreaks.

Cadmium is present only in traces in soils and, therefore, would not be expected to be present in appreciable quantities in plant products. Its presence in human tissues and rat tissues which have been examined, has not yet been revealed. There is no information concerning its nutritive significance, and the only interest in cadmium from a biological viewpoint is that it can readily cause both acute and chronic toxicity when present in small quantities in the form of its soluble salts.

The toxicology of cadmium is most interesting because of the acute symptoms which result soon after the ingestion of very small amounts. The history of cadmium poisoning has been discussed by Prodan[1]. Recently five outbreaks of cadmium poisoning have been reported[2]. In these outbreaks at least 50 persons were involved. The smallest concentration of cadmium which produced noticeable effects was 15 p.p.m. in certain materials. In the other four outbreaks, the cadmium content of the

materials ingested was respectively 67 p.p.m., 160 p.p.m., 300 p.p.m. and 530 p.p.m. The different types of material consumed were flavored frozen ices, lemonade, punch, and gelatin dessert. The quantities consumed were apparently small since it would not be expected that a person would consume large quantities of frozen ices. In a recent instance which has been reported[3], 208 men showed symptoms of cadmium poisoning after drinking lemonade which had been stored in cadmium-plated metal containers for only about 1½ hours. The lemonade contained 100 p.p.m. of cadmium and when left in the containers for 24 hours, it was found to contain 250 p.p.m. The onset of the symptoms often occurs within 10 minutes after the ingestion of the material. The syndrome appears as violent acute gastritis with nausea, cramps, vomiting, diarrhea, and weakness and is often accompanied by metallic taste. Another instance has been reported to the Food and Drug Administration in which 18 men showed symptoms of cadmium poisoning after consuming foods placed in cadmium-plated containers.

Chronic toxicity studies on rats and dogs have demonstrated that deleterious effects are shown when animals ingest as low as 15 p.p.m. of cadmium in their diet.

The containers reported to be at fault most commonly so far have been cadmium-plated ice-cube containers (new and replated), but special containers of different types used as food and liquid carriers, which are now on the market, have been involved. Likewise a cadmium-plated water pitcher was involved in one instance. Attention has been called, in addition, to cadmium-plated meat grinders, food choppers, and food mixers.

Because of the very high toxicity of cadmium, both from the acute and chronic standpoint, there should be no use of cadmium food containers of any kind; this is especially important for those foods containing acids. The October 1941 issue of New Hampshire Health News states that the New York City Sanitary Code has been amended so as to prohibit the used of cadmium in containers for foods and drink, and adds "At that time the plating industry was called into conference and it is likely that this practice will be discontinued throughout the country as a whole. If it should subsequently appear that it is continued. then a regulation against it will be made by this Department." If cadmium, which is a defense metal, were not released for the manufacture of cadmium-plated food containers, this would go a long way toward the solution of the problem in the near future, but it would not take care of the existing cadmium-plated materials which are available and it would not solve the problem for the future after the emergency has passed. Everyone should be warned of the possible dangers of this material so there will be no future use of it under any circumstances in or on food and beverage containers.

1. L. Prodan, Cadmium Poisoning: 1. The History of Cadmium Poisoning and Uses of Cadmium. J. Ind. Hyg. **14**, 132, April (1932).
2. S. Frant and I. Kleeman, I. Cadmium "Food Poisoning". J.A.M.A. **117**, 86, July (1941).
3. J. T. Cangelosi, U. S. Naval Med. Bull. **39**, 408 (1941).

Use of Rectifiers for Anodizing

(*Concluded from page* 130)

U. S. specifications. Furthermore, at least one agency recommends chromic acid anodizing at 30 volts.

Regarding cost of equipment, sulphuric anodizing being somewhat faster than chromic and capable of securing heavy current densities at rather low voltages, was supposed to cost less for equipment per unit of daily production than the chromic method. Today, unless the process happens to be taking place above a subterranean water table of almost icy temperature, considerable mechanical refrigeration must be added to the outlay for equipment, and it is quite possible that in a number of cases the equipment cost of the sulphuric system per pound of work per day will be higher than where the chromic acid process is employed.

These factors are discussed merely as generalities. They are not intended to form the basis for selection of one method over another. This selection is extremely likely to be covered by Governmental specifications anyhow, and the contractor may have very little latitude in the matter. We merely warn against the danger of pontificating, "sounding-off", on the subject of what is and will be required for anodizing equipment. What we know today may be unlearned tomorrow as methods change and sources of supply are shot up in the processes of war.

Rectifiers as Building Blocks of Power

However, we can make a few cautious remarks about the rectifier in its application to the shifting specifications in this more or less novel art. As previously stated, rectifiers serve best when they are manufactured and offered to the trade as electrical building blocks of standardized size. From these blocks of power it is possible to assemble larger units of power, usually in multiples of six volts. No matter whether it is to be sulphuric anodizing at 24 volts or chromic anodizing at 40 volts, by a simple arrangement or rearrangement of the building blocks the required size of electrical generative equipment can be assembled.

During the anodizing process, when the voltage is being raised, the limiting increment conveniently possible is six volts minimum. Such an increment conceivably might create a surge level out of all proportion to the value of steady-state current assigned to the normal tank load. But there is an inherent compensation for this assumed condition, lying in the basic voltage regulation of the rectifiers themselves. Added to this decisive factor it has been found possible to use surge suppressors to aid in whittling down the surges to values somewhere nearer the steady-state current at which the system is supposed to do most of its anodizing. These surge suppressors are very simple articles, containing no moving parts.

Thus we have with us in America a source of anodizing amperes that not only serves to relieve the critical demand for generators but also can claim decided specialized advantages of its own. There are several makes of rectifiers which can be adapted to the anodizing art, and all are helping to supply the unprecedented demand that December Seventh, 1941, dropped into the lap of the American metal finishing industry.

Patents

Cleaning Metal Strip

U. S. Pat. 2,259,260. E. A. Matteson and K. B. Bowman, assignors to The Aetna Standard Engineering Co., Oct. 14, 1941. A process of continuously cleaning longitudinally moving strip metal which includes the step of passing the strip through an alkali bath, and, while the strip is submerged in this bath, generating heat in the strip itself whereby boiling of the alkali bath will occur adjacent the surfaces of the strip.

Tarnish Resistant Silver Alloy

U. S. Pat. 2,259,668. J. Spanner (Germany), assignor to Chemical Marketing Co., Inc., Oct. 21, 1941. A tarnish resisting silver alloy comprising 25% to 60% silver, 10% to 50% palladium, 10% to 40% cadmium, 5% to 30% copper and 0.1% to 10% of a precious metal selected from the group consisting of gold and platinum, said silver, palladium, cadmium, copper and precious metal constituting substantially all of the alloy.

Treating Pickling Wastes

U. S. Pat. 2,258,310. F. C. Abbott, assignor to Ozark Chemical Co., Oct. 7, 1941. A method of treating spent pickle liquor which comprises addition of magnesium hydrate to form a slurry, dehydration and separation of the iron hydroxide by addition of water to redissolve the magnesia, addition of ammonium hydroxide or ammonia gas to precipitate the magnesium hydrate and separation from the ammonium sulfate solution.

Metal Spraying

U. S. Pat. 2,262,964. J. T. Reilly & C. M. Weese, assignors to Universal Joints and Motor Parts Co., Nov. 18, 1941. An improvement in the construction of metal spray guns.

Electroforming

U. S. Pat. 2,260,893. H. O. Ewing, Oct. 28, 1941. A method of producing hollow radiator bodies by deposition on a fusible core of the desired shape, then masking the deposit and building up additional thickness of deposit on the unmasked portions, followed by heating to remove the core.

Surface Testing Machine

U. S. Pat. 2,261,093. O. J. Poupitch, assignor to Illinois Tool Works, Oct. 28, 1941. A surface contour testing machine with a coupled recording device.

Cyanide Copper Bath

U. S. Pat. 2,255,057. D. A. Holt, assignor to E. I. duPont de Nemours & Co., Sept. 9, 1941. A cyanide copper solution containing 0.01 to not more than 1 oz./gal. of a betaine having at least one non-cyclic hydrocarbon radical which contains 10 to 20 carbon atoms, such as 0.02-0.2 oz./gal. trimethyl-C-cetyl alpha betaine, trimethyl-C-decyl alpha betaine or dimethyl-N-stenyl alpha betaine. These materials prevent pitting.

Examples:

	I.	II.	III.
Sodium cyanide	17 oz./gal.	18 oz./gal.	17.5 oz./gal.
Copper cyanide	16 "	16 "	16 "
Caustic soda	4 "	4 "	4 "
Sodium thiocyanate	2 "	2 "	2 "

Trimethyl-C-cetyl alpha betaine—1-20 cc. of 25% water solution is added to Formula I
Trimethyl-C-decyl alpha betaine—2-4 cc./-gal. of 25% water solution is added to Formula II.
Dimethyl-N-stenyl alpha betaine—0.2-10 g./-gal. is added to Formula III.
Temperature: 70°-80° C.
Anodes: Electrolytic cathode copper.
Current Density: 15-45 amp./ sq. ft.
Anode: Cathode Ratio: 3:1.

Plating Machinery

U. S. Pat. 2,267,190. J. A. Claffy, assignor to Mercil Plating Equipment Co., Dec 23, 1941 An apparatus for transfer of articles in bulk from one tank to another by means of pivoted, perforated hoppers driven by a shaft and crank on the outside of the tank.

Buffing Wheel

U. S. Pat. 2,260,941. F. E. Hendrickson, assignor of one-half to M. Ireland, Oct. 28, 1941. A hard buffing wheel of annular disks, all of the same outer diameter but some of lesser inner diameter than others.

Anodizing Aluminum

U. S. Pat. 2,260,278. M. Schenk (Switzerland), assignor to Ematal Electrochemical Corp., Oct. 21, 1941. Production of opaque, hard and protective coatings on aluminum and alloys by subjecting the article as an electrode to the action of an electric current in an aqueous solution of zirconium sodium oxalate, boric acid, crystallized borax and dextrine at 10-95° C. (preferably 72°) and 6 amp./sq. dm. as anode until the current density at full voltage has dropped to half its normal value.

Example: Anodize at 120 volts, 72° C., 6 amp./sq. dm. in:

Zirconium sodium oxalate	16 Kg.
Boric acid	16 "
Borax, crystalline	16 "
Dextrine	4 "
Water	800 liters

The films may be dyed or painted.

Manganese Bath

U. S. Pat. 2,259,418. W. H. Hannay & B. J. Walsh (Canada), assignors to The Consolidated Mining & Smelting Co. of Canada, Ltd., Oct. 14, 1941. A process of producing manganese by electrolyzing a solution of manganese sulfate and ammonium sulfate at pH 4 to pH 8 in a cathode compartment, using an anode compartment containing sulfuric acid solution, removing depleted catholyte and replenishing it with manganese sulfate while water additions are made to the anolyte to react with the sulfate which migrates to the anode compartment, the accumulated sulfuric acid being removed at intervals.

Silver Plating Bath

U. S. Pat. 2,259,270. J. Ryder, assignor of one-half to L. B. Davis and R. H. Galbreath, Oct. 14, 1941. An electroplating solution for producing tarnish resistant silver alloys consisting of silver fluoride, tin fluoride, tartaric acid, uranium hydroxide, boric acid and water. Also with the addition of dextrose.

Example:

Silver fluoride	3	troy oz.
Stannic fluoride	2	" "
Tartaric acid	4	" "
Dextrose	0.5	" "
Uranium hydroxide	2	" "
Boric acid	0.5	" "
Water	1	gallon

Insoluble anodes are used at room temperature and a cathode current density of 2-3 amp./sq.ft. The fluorides may be prepared by precipitating the metal hydroxides and dissolving in hydrofluoric acid.

Pickling Aluminum

U. S. Pat. 2,257,960. W. M. Humphrey and R. E. Lee, October 7, 1941. A method for removal of oxides from aluminum by a material comprising phosphoric and phosphorous acids, a fluoride reactive with such material and a colloidal clay, said composition supplying available fluorine for cleaning aluminum surfaces.

Example:

Cryolite (200 mesh) ..... 1 part by weight
Phosphoric acid, 75-85% . 2 parts by weight

Allow to stand for 24 hours and decant the excess liquor. Add 200 mesh bentonite until the residue is dry or in paste form.

Corrosion Prevention of Magnesium

U. S. Pat. 2,261,960. R. W. Buzzard, Nov. 11, 1941. A method for producing corrosion resisting coatings on magnesium or its alloys comprising coating in a water solution of a dichromate and phosphate, or dichromate and nitric acid and then sealing the primary coating by anodizing in a solution of a water soluble chromate, dichromate, fluoride and borates.

Example:

Sodium dichromate 10%
Monosodium phosphate 2%

Immerse at boiling, rinse and anodize in the sealing solution.

Example: Sealing Solution:

(a) 10% dichromate and 1% chromium fluoride
(b) 5% chromium fluoride
(c) 5% dichromate and 5% borate
(d) 5% borate
(e) 20%-75% dichromate
(f) 10% dichromate and 2%-5% phosphate.

Anodizing Aluminum

U. S. Pat. 2,262,967. M. Schenk (Switzerland), assignor to Ematal Electrochemical Corp., Nov. 18, 1941. A process of producing opaque, enamel-like, hard and protective coatings containing oxide of thorium on articles of aluminum or its alloys, which comprises immersing said articles in an aqueous bath containing thorium ammonium oxalate, citric acid, crystallized borax and glycerine, at 68 deg. C and 120 volts D.C. at a current density of 3.5 amps./sq. dm. until the current density at full voltage has dropped to half the original value.

Example:

Thorium ammonium oxalate	12 Kg.
Citric acid	15 "
Crystallized borax	15 "
Glycerine	20 "
Water	800 Liters

Metal Spraying

U. S. Pat. 2,262,072. T. H. Vaughn, assignor to Union Carbide and Carbon Research Laboratories, Inc., Nov. 11, 1941. A process which comprises spraying molten metal particles onto an article to be coated therewith by means of a jet of gas impregnated with a volatile flux comprising at least 1 ester selected from the group consisting of the alkyl esters of boric acids and the alkyl esters of silicic acid.

Corrosion Prevention of Steel

U. S. Pat. 2,257,133. R. W. Shoemaker, assignor to Agnes J. Reeves Greer, Sept. 30, 1941. The inhibition of rusting of pickled metals comprising rinsing in a solution containing caustic alkali, a polyhydric alcohol taken from a group consisting of glycerine and glycol and a wetting agent (?) taken from a group consisting of sodium metaphosphate and sodium hexametaphosphate. Also in a solution of alkali, soap and wetting agent followed by coating with a solution containing glycerine or glycol.

Example:

After pickling, rinse in a hot solution of:

Water	5600 gal.
Soap chips or powder	10- 20 lb.
Caustic soda	50-150 "
Wetting agent	10- 20 "
or Calgon (Sod. hexametaphosphate)	5- 10 "

Follow this rinse by a second hot rinse containing:

Water	4800 gal.
Soap powder or chips	5- 15 lb.
Caustic soda	15- 30 "
Wetting agent	5- 20 "
or	
Calgon (Sod. hexametaphosphate)	5- 10 lb.
Glycerine or glycol	10- 25 gal.

This solution is allowed to dry on.

Strip Pickling

U. S. Pat. 2,264,857. N. J. Ranney, assignor to The Wean Engineering Co., Inc., Dec. 2, 1941. An improved apparatus for electrolytic pickling of strip steel.

Coloring Nickel and Alloys

U. S. Pat. 2,266,117. C. G. Crocker, G. K. Crosby & R. R. Clappier, assignors to The International Nickel Co., Inc., Dec. 16, 1941. Coloring of alloys containing at least about 98% nickel and not substantially more than 1% magnesium by exposing to an oxidizing atmosphere in an enclosed furnace at a controlled temperature within the range of about 1500° F. to about 2100° F. for a controlled period of about ½ min. to about 4 min. until the desired color is obtained.

Linings for Plating Tanks

(*Concluded from page* 128)

a plater tells you that he got poor results from a rubber lining or a synthetic lining or a brick lining, don't conclude immediately that these substances are no good. In one plant here in Los Angeles there are rubber lined tanks that have been in use for years and are still good, and this plant has had other rubber lined tanks that lasted only a few months under exactly the same conditions. A tank lining, like a plated coating, may be good or bad depending on how it is put on.

Then too, remember that electricity can play queer tricks on a metal tank or metal lining. A tank may be entirely impervious to the action of a solution as long as no electricity is applied to it but when current is applied, an action may start immediately. And the current does not have to come from a direct connection to the generator. It may be current from the anodes through the solution or from contact with a gas pipe that has been used as a ground for some electrical machine somewhere in the shop, or just through a wet floor on which the tank is resting, or a hundred and one other places that would tax the detective powers of Sherlock Holmes to discover and eliminate. For this reason, wherever it is practical to line a tank with something that will not conduct electricity it is advisable to do so, and where the tank or lining must be made of metal, every precaution should be taken to insulate and isolate it from every source of electric current except the one you want.

Hydrogen Embrittlement

(*Concluded from page* 127)

temper brittle range of 500 to 550° F., except in steels that are not subject to a temper brittle range, such as molybdenum bearing steel. In such case, maximum susceptibility occurs at a much lower drawing temperature or perhaps at no draw.

(3) Susceptibility to embrittlement increases with the hardening constituents, primarily carbon.

(4) Hydrogen embrittlement will tend to dissipate on standing at room temperature and can be hastened by heating.

(5) Complete relief of hydrogen embrittlement depends upon the embrittling medium or type and thickness of plate.

(6) Temperature is a much more potent factor than time in relief treatments.

(7) Hydrogen embrittlement effect increases with decreased section.

(8) Hydrogen embrittlement in steels heat treated to a hardness of 40 Rockwell C or under is negligible in most cases. This statement is restricted to heat treated steels since there is evidence that cold worked material is susceptible to hydrogen embrittlement at lower hardness than the same material heat treated to a corresponding hardness.

Acknowledgment

The author wishes to express his appreciation for the cooperation received from the management, metallurgical staff and heat treating department of Pratt & Whitney division, United Aircraft Corp., where this work was initiated, and to Jacobs Aircraft Engine Co., where it was continued. Acknowledgment is also given Republic Steel Co., Bethlehem Steel Co. and Wallace Barnes Co., for material and suggestions; International Nickel Co., MacDermid, Inc., and Pratt & Whitney division, Niles-Bement-Pond Co., for the treatment of test specimens; and to the Bullard-Dunn Process division of the Bullard Co., for treatment of specimens and permission to publish data about their process.

PLATING AND FINISHING
POLISHING — BUFFING
CLEANING — PICKLING
HOT DIP FINISHES

SHOP PROBLEMS

Barrel Gold Plating

Q. We are faced with the problem of plating small parts which would be most suitably plated in barrels. Kindly advise the procedure for this and also the best way of lacquering small parts. What formula do you recommend for immersion gold plating, and advise us the exact weight of gold in one ounce of gold cyanide.

A. Barrel gold plating can be done in small barrels made for this purpose, and usually listed by plating supply houses as "jewelers' barrels." For information on these get in touch with supply houses many of whom advertise in Metal Finishing.

The following solution can be used. This is as given on page 43 of the Plating & Finishing Guidebook, 1941 edition:

Potassium gold cyanide	½ to 1 oz.
Potassium cyanide	½ to 1½ "
Water to make	1 gal.

Temperature 140 to 160° F. Current density 1 to 5 amps./sq. ft. See the Guidebook for other details of operation.

This formula is subject to variation to suit the type of work being handled.

After plating, the work is dumped into a basket (iron) held over the tank so that no drippings are lost. Then rinse in 2 or more drag-out tanks. Dry in sawdust, or in hot air blast if sawdust cannot be used. Alcohol drying is good if the alcohol can be obtained.

Lacquering can be done by dipping the work, in baskets, then after a short drain, twist the basket vigorously or centrifuge. Machines for dipping and centrifuging are on the market.

Formula for immersion gold (as from page 44 of the Guidebook):

Potassium gold cyanide	½ oz.
Potassium cyanide	5 "
Potassium carbonate	6 "
Water to make	1 gal.

Boil before using. Operate at 180° F.

Gold content of cyanide salts:

	Theoretical	*Commercial Grades*
Gold cyanide	88.35%	88.0%
Potassium gold cyanide	68.4%	41% and 67%

Silver Plating of Brass

Q. Please recommend proper methods for silvering of brass pieces, a sample of which is enclosed. Can thicknesses of silver from 0.0003" to 0.0007" be obtained by barrel methods. Under separate cover we are sending a sample of our silver solution which has been used for general job plating and various types of metals.

A. The parts should be bright dipped after alkaline cleaning in the regular manner and cyanide dipped before silver plating. It may be possible to plate the parts in a barrel but it is questionable whether it can be done in one operation. For light plating, a solution low in metal and high in cyanide such as 1 oz./gal. of silver and 5 oz./gal. of free sodium cyanide is satisfactory for barrel plating. However, because of the low metal content, which is necessary to avoid blistering due to an immersion deposit, it is questionable whether a good deposit of the thickness desired can be produced in this solution. It may be necessary to strike in the first barrel and then transfer to another barrel containing about 3 or 4 oz. of metal per gallon with the same free cyanide content as the strike barrel.

After plating, the work should be rinsed in cold water and then in hot water containing about ¼ oz./gal. of soap flakes, after which it may be dried. A centrifuge may be used for drying or the parts may be dried in alcohol or in an oven.

We are unable to give any cost figures because this will be dependent on the particular shop conditions involved.

The sample of plating solution contains 5.12 troy oz./gal. of metallic silver and 2.83 av. oz./gal. of free cyanide. The metal content is rather high for jobbing work and in addition due to the age of the solution the accumulation of carbonates and impurities will cause granular deposits. We would suggest that you remove 40 gallons of solution and replace with water. Then add 1½ oz./gal. of sodium cyanide. This will give you a metal and free cyanide content of 3 oz./gal. each approx., and at the same time will reduce the impurities and carbonates by 40%. Use carbon disulfide brightener as recommended in the Plating and Finishing Guidebook.

Technical Advisor For March Issue

G. B. HOGABOOM, JR.,
Consultant in Electroplating, and Metal Finishing
Newark, N. J.

Silver Plating Carbon Brushes

Q. We were recently faced with the problem of silver plating carbon brushes. Would a silver strike and a few thousandths of silver plate adhere sufficiently for the use of this brush? Do you advise a copper sulphate strike prior to silver plating?

A. Neither silver striking nor a preliminary acid copper plate on carbon brushes will give a good bond for a subsequent heavier deposit of silver. If the brushes are of the copper-graphite type the bond will be still more doubtful due to the greasy nature of graphite.

The silver striking procedure is less desirable as the strong alkali will attack the binder of the brush and this plus absorption of alkali in the pores of the brush will have a detrimental effect. The acid copper solution will not be so bad in this respect.

The mechanical properties of electrodeposits are not as good as those of the rolled metal. Therefore to have a silver coating on a brush with reasonable strength, it would have to be 0.004"—.005" thick. A heavy copper plate can be used, followed by silver plating.

Analysis of Zinc Solutions

Q. Will you please help us regarding the following analytical problems.

1. What is the method for the analysis of zinc in nickel plating solutions and can the procedure used in brass solutions be employed for zinc and nickel solutions?
2. What is the procedure for determining sodium sulphate in nickel plating solutions?
3. How is the bromcresol purple indicator made that is used in the determination of boric acid in nickel plating baths?

A. Zinc may be determined in nickel plating solutions by adjusting some of the solution to pH 2 with citric acid, after which a 50 cc. sample is taken for analysis. 75 cc. of distilled water is added to the sample in a 400 cc. beaker and hydrogen sulfide gas is passed in for about 20 minutes. The precipitate of zinc sulfide is filtered off and washed with warm distilled water containing a small amount of hydrogen sulfide, after which it is ignited at about 900° C. and weighed as zinc oxide (ZnO).

There is no accurate way of determining sodium sulfate in nickel plating solutions unless this is the only sodium salt present, that is if the chloride is present as ammonium or nickel chloride. In this case the sodium can be determined quantitatively by any of the standard procedures. Ordinarily the total sulfate is determined and the amount present as nickel sulfate is subtracted from this figure. Since the sodium sulfate content in a die cast nickel solution is not critical many platers keep the Baume of the solution at a value numerically equal to about 5 times the metal content.

The bromcresol purple indicator used for boric acid determinations is a Clark & Lubs Indicator Solution and contains 0.04% by weight of dibromo-o-cresolsulphonphthalein neutralized with sodium hydroxide. The solution is prepared by mixing in a mortar 0.1 gram of the dry powder with 18.5 cc. of 0.01 *N* caustic soda and then diluting to exactly 250 cc. with distilled water.

NEW EQUIPMENT AND SUPPLIES

NEW PROCESSES, MATERIALS AND EQUIPMENT FOR THE METAL INDUSTRY

New Emulsion Cleaning Concentrate

MacDermid, Inc., Waterbury, Conn., have announced the development of a new water soluble concentrate called "Macosol" (formerly known as Solvtex W), which is designed specifically for the removal of oil and grease from metal surfaces using a water emulsion. It is claimed to be entirely neutral in character and thus may be used even on aluminum or magnesium without attack on these metals.

In ordinary applications, the recommendations for use in cleaning are to use 10% by volume of this concentrate in water at a temperature of 160-180° F. For heavy duty applications where chunks of grease and other materials, which are difficult to remove, are present, it may be necessary to increase the concentration to 20-25%. For the heaviest duty such as the removal of carbon and similar deposits, the concentration may be as high as 50% Macosol in water. Following the cleaning bath, the work should be rinsed in two hot water rinses or if these are not available, cold water sprays reaching every part of the articles are satisfactory.

A special application, the company states, is a rust-proofing compound for iron or steel parts which are ground or machined dry or with kerosene and are subject to rusting. An emulsion of this cleaning concentrate containing 3-5% by volume is used for this purpose. A cold solution may be used, but the best results are obtained by using the emulsion hot in order that the parts may dry free from water, leaving only a thin oily film which will not harden. This film may be easily removed at any subsequent time by merely rinsing in water as previously described for procedure following the cleaning operation. Applications not previously mentioned include the use as a cleaner prior to rust-proofing processes and the use to clean and rust-proof steel parts from which the cutting oil must be removed for inspection. In this latter case, the parts may be put through the cleaning cycle and allowed to dry without rinsing—thus leaving a thin rust-proofing film, which is claimed not to interfere with gauging, and which is perfectly soluble in cutting oil or soluble oil which may be used in subsequent operations. For use where the parts have to be brushed in the cleaner to remove the dirt, it may be operated cold or at a temperature up to about 115° F. The product is said to have no harmful effect on the hands and rubber gloves need not be provided.

Further details of application to specific problems will be furnished on request. It is sold as a clear, brown liquid concentrate in 400-lb. returnable drums.

Direct Blackening Process for Copper and Copper Alloys

The Enthone Co. 442 Elm St., New Haven, Conn., have just announced the development of a new process called Ebonol "C" for simple, direct, low temperature, chemical blackening of copper and copper alloys. The process involves immersion in a solution of blackening salts operated near the boiling point or from 200 to 212° F. and the blackening is accomplished in from 2 to 10 minutes depending upon the alloy being blackened.

The process is stated to be suitable for blackening copper, beryllium copper, bronze, phosphor bronze, and brasses with zinc contents of 35% or less. High brasses are colored a pleasing chocolate brown. The coating produced is, according to the manufacturer, unique in its properties. The coating is essentially cupric oxide, and being integral with the base metal, it cannot chip or flake. In addition to being jet black, the coating is hard enough to be buffed and does not have to be lacquered to prevent wear as is the case with copper sulphide type finishes.

The company believes that the finish should be of considerable importance in the production of War Goods, such as optical equipment, airplane instruments, detectors, as well as for essential civilian use. It is suitable for parts that must withstand close dimensional tolerances, that will be handled to a large extent, for parts that must be deformed without the coating flaking, and wherever a jet black coating is required. An unusual feature is that the finish can be heated to almost dull red heat without flaking, and continuous exposure to temperatures as high as 600°F. will not harm the finish.

Non-copper alloys capable of being copper plated can be readily blackened by first copper plating and then blackening the copper. Inasmuch as no electric current is involved in the blackening process, small parts can be blackened in baskets or in horizontal or oblique barrels, and large parts, of course, are blackened on racks or hooks, or stacked in baskets.

It is claimed that the overall cost of blackening is less than black nickel plating, or copper plating and sulfur oxidizing. The work is prepared for blackening by simple cleaning or bright dipping, and the solution can be contained in an ordinary steel tank heated with closed steam coils.

The company is prepared to blacken samples for anyone interested and to give advice on the blackening of all metals.

Rust Preventive Cream

The Milburn Co., 905 Henry St., Detroit, Mich., have announced the development of a rust preventive cream entitled, "Ply-Rustex", which is applied to the hands of the worker before contact with highly polished metal surfaces to prevent rusting from perspiration.

The worker applies the cream to his hands before touching any part of the article to be machined or processed, and this technique is stated to enable free handling of the metal throughout the machine operation without gloves. The invisible film formed on the skin is said to act as a protective coating that is inert to chemicals, alloys and cutting compounds.

The material is claimed to be non-toxic and harmless to the skin, to be easy to apply and can be removed with equal facility. Because it forms an impervious protective coating, it is reported also to inhibit many forms of industrial skin dermatoses.

Professional Directory

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SALT SPRAY TESTING — CERTIFIED TO MEET ARMY AND NAVY SPECIFICATIONS. Testing of deposits-thickness, composition, porosity. Solution analyses, plant design, process development.
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Platers Technical Service Co.
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Complete services, including solution analyses, process development and deposit tests.
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Plating plants streamlined for defense work.
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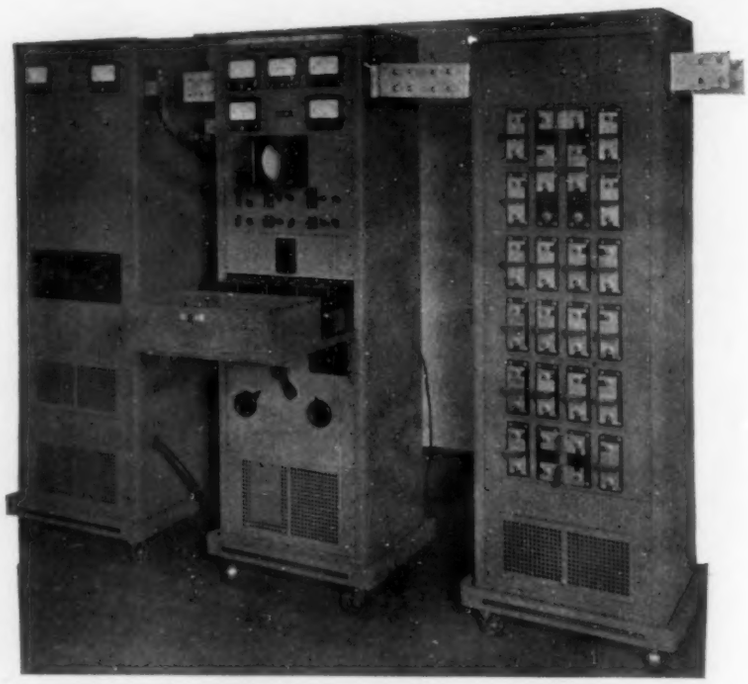
Checking Performance of Selenium Rectifiers

The W. Green Electric Co., 130 Cedar St., New York, recently completed new test equipment for checking the selenium rectifiers "Selectro-Platers" made by the company.

Before shipment, every rectifier unit undergoes full load tests in which the following factors are checked:

1. Control circuit operation
2. Meter accuracy
3. Voltage range control
4. Efficiency at several loads
5. Power factor at several loads
6. Temperature rise inside unit
7. Thermostat adjustment
8. Wave shape and rectifier balance

The photograph shows an 18 volt—200 ampere—3 phase rectifier unit undergoing test. (This unit was ordered by one of the Government bureaus for laboratory use.) On the extreme left in the photograph is the rectifier unit on test and on the extreme right is shown a cabinet housing the "Dummy Loads." The dummy load consists of nichrome resistors which can be connected by means of silver plated links shown on the front of the cabinet to obtain any desired load up to 24,000 watts. Thus, for example, the maximum load can be varied from 6 volt—4000 amperes to 48 volt—500 amperes. The resistors are cooled by a fan located at the bottom and the various resistor units and fan are contained in the company's standard No. 5 cabinet which ordinarily houses a 6 volt—1000 ampere rectifier unit.



Photograph showing a "Selectro-Plater" being tested on the left, the test apparatus in the center, and the dummy load on the right.

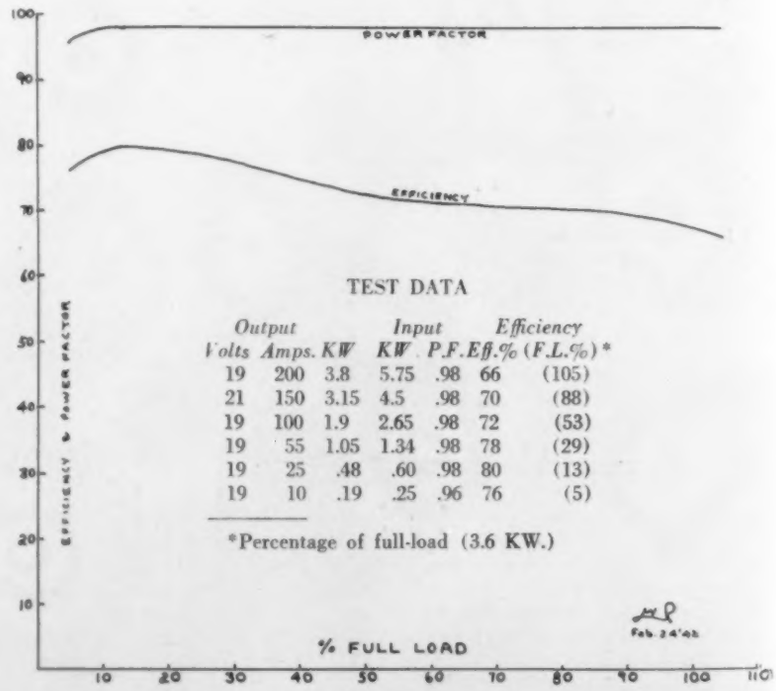
Test Unit

In the center of the photograph is shown the Test Unit. At the top of this unit can be seen a row of ammeters for measuring current in 3 ranges, namely 0 - 150, 0 - 750 and 0 - 4000 amperes. Just below the three meters are two voltmeters for measuring rectifier output voltage. The meters have ranges of 0 - 15 and 0 - 60 volts respectively. The black box houses the tube end of the cathode ray oscilloscope, which shows visually the wave shape of the rectifier output. The oscilloscope also shows relative performance of individual banks of rectifiers in a unit, and any lack of balance is indicated visually by lack of symmetry in the oscilloscope pattern.

The various meters and key switches below the oscilloscope make up the 3-phase analyzer which measures input voltage, current, kilowatts, power factor and efficiency.

Facilities are also available for measuring stack temperatures which normally rise from 25 to 30° C. above room temperature during full load operation of standard rectifiers.

Below are given some data obtained during the test on the 18 volt—200 ampere unit shown above:



TEST DATA

Output			Input		Efficiency	
Volts	Amps.	KW	KW	P.F.	Eff.%	(F.L.%)*
19	200	3.8	5.75	.98	66	(105)
21	150	3.15	4.5	.98	70	(88)
19	100	1.9	2.65	.98	72	(53)
19	55	1.05	1.34	.98	78	(29)
19	25	.48	.60	.98	80	(13)
19	10	.19	.25	.96	76	(5)

*Percentage of full-load (3.6 KW.)

Curves showing efficiency and power factor for "Selectro-Plater" 18200T No. 206 for various loads.

Cylindrical Polisher

Hammond Machinery Builders, Inc., 1601 Douglas Avenue, Kalamazoo, Michigan, have announced the development of a new "OD" cylindrical polishing machine capable of handling ¼" to 9" outside diameter cylindrical shapes, rods, and tubes; especially adaptable to the use of abrasive belts with back stand attachments, polishing or buffing wheels. The range of feed of this machine is said to be 0 to 50' per minute, forward or reverse. One of the features claimed is that the machine is designed to permit an inexperienced operator to secure quality finishes at high production rates.

The polisher is claimed to be a substantial, sturdy machine, using for the polishing members, various types of wheels and abrasive belts required in finishing the work on the machine. The wheel head mounting is heavy and rugged with a large spindle running in precision ball bearings properly lubricated with oil and sealed to prevent ingress of dust and dirt. A slide provides quick adjustment of the polishing and/ or patented cushion wheel (6" face x 12" to 16" diameter).

Cylindrical polishing machine

The "Vari-Matic" feed is motor driven through a variable speed drive, allowing various speeds of rotation of work as well as feed. A quick release lever enables the operator to control the work being fed through the machine by disengaging the work from the face of the wheel.

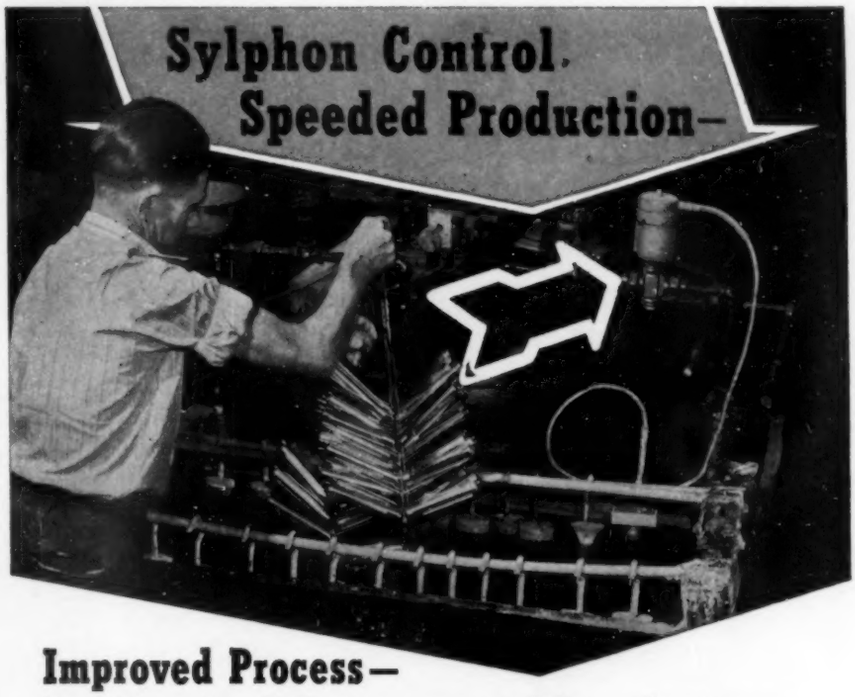
The work support is adjustable to the wheel by quick simple means for work of varying diameters. The particular style or type of work support is either the company's standard support, or specially built for the customer's requirements.

All parts are carefully guarded and readily accessible. The wheel cover can be quickly removed for changing wheels and abrasive belt.

Synthetic Tubing

The United States Stoneware Co., 60 E. 42nd St., New York, have announced the availability of "Tygon" tubing in ¼" I.D. and ½" I.D. sizes, and other sizes are being added as fast as the demand warrants.

Tygon is a synthetic rubber-like material



Improved Process—
for Surgical Instrument Manufacturer

Eight years ago, Becton Dickinson and Co., Rutherford, N. J., installed Sylphon Controls on their electro cleaning tanks where metal parts are cleaned prior to plating.

This accurate, automatic control of temperatures immediately permitted stepping-up production and provided more uniform cleaning results, reflected in a better plating job.

Perhaps you have a similar situation in your own plant where Sylphon automatic control can be an invaluable investment. Over 200,000 Sylphon installations through Industry are evidence of the widespread usefulness of these simple, dependable, inexpensive controls.

Ask a Fulton Sylphon Representative to call or write for Bulletin EA-20.

FULTON Sylphon FOR TEMPERATURE CONTROL

THE FULTON SYLPHON CO.
KNOXVILLE, TENNESSEE
Representatives in All Principal Cities in U.S.A. and in Montreal, Canada and London, England

NEW DIRECT CURRENT PANEL BOARDS

Consisting of one DC 0/15 Volt VOLTMETER and one DC AMMETER with Shunt and Leads mounted on 10" x 6" x ½" thick Ebony Asbestos Panel Stock. Prices:

0/100	Amp. range	$15.00
0/200	" "	17.50
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0/500	" "	25.00
0/750	" "	27.50
0/1000	" "	30.00
0/1500	" "	37.50

Prices F.O.B. Cambridge, Mass.

These panel boards are excellent for Plating Barrels and Plating Tanks.

Guaranteed.

M. E. BAKER COMPANY
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The FINISH that will add instant sales appeal to *your* product.

EBONOL

REG. UNITED STATES PATENT OFFICE

THE JET BLACK CORROSION RESISTANT FINISH FOR IRON AND STEEL

Leading manufacturers of appliances, bicycles, coffee makers, radios, guns, bearings, buckles, buttons, tools and hardware, are using EBONOL to beautify their products and replace zinc, cadmium, nickel and other finishes.

Plants now doing plating need only ONE new tank to start using EBONOL.

Some proven advantages of EBONOL:

Fast Blackening by Immersion in Only ONE Bath
Deep Penetration—No Red Stains
Highest Corrosion Resistance
Simple and Economical to Operate

Send sample parts to be EBON-ized and let our finishing engineers serve you.

THE Enthone COMPANY

NEW HAVEN CONNECTICUT

that possesses, it is claimed, better chemical resistance than rubber.

Various corrosive materials, such a nitric, hydrofluoric, hydrochloric and sulphuric acids, alkalies, hydrocarbon solvents, oils, etc., can, it is reported, be handled with perfect safety.

The material is also available in sheets in thickness of 3/32" and in any size up to 30" x 60". Both the tubing and the sheet can be had in varying degrees of hardness and resiliency.

Anodizing Aluminum with Alternating Current

A simple low-cost method of anodizing aluminum and aluminum alloys using alternating current has been developed by Colonial Alloys Co., E. Somerset, Trenton Ave. & Martha Sts., Philadelphia, Pa.

This process is stated to be applicable for Government work specification No. AN QQ-S-696a, sulfuric acid type of anodizing. Some of the features claimed are:

1. No rectifier or motor generator is required. A low-cost AC transformer at about 25 volts is used.
2. Close control of temperature of the solution is not necessary and a temperature rise of 20° F. is permissible.
3. The coating produced is stated to be very fine with good hardness and corrosion resistance and with a high ratio of dielectric strength to thickness of coating.

Cement-Asbestos Pipe

The United States Stoneware Co., Akron, Ohio, have announced a new line of cement-asbestos pipe, known as "Roxite". It is manufactured by a patented high pressure process, giving this pipe higher density and greater mechanical strength than other cement-asbestos pipe, according to the manufacturer.

Patented "Flexlock" sleeves and fittings are used to couple the pipe, no special tools being necessary for assembling. This method of coupling is said to do away with the need for any special treatment or threading of the pipe ends.

Standard Roxite pipe is specially designed for the handling of a wide range of mildly corrosive solutions, for transporting pro-

PERMAG Cleaning Compounds

for Manufacturers Handling Defense and War Contracts

PERMAG Cleaning Compounds are adapted for cleaning metals used in the vast aircraft industry.

Special fast action PERMAG Cleaners are used for cleaning brass, steel, aluminum and aluminum alloys which are used in the manufacture of essentials for defense.

There is a PERMAG Cleaning Compound made for every metal cleaning requirement. Let us send full details.

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Manufacturers of Specialized Scientific Cleaning Compounds for Industrial Purposes
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In Canada: Canadian PERMAG Products Ltd., Montreal and Toronto.

cessing water which must be kept free of metallic contamination, etc. The corrosion resistance of the pipe also makes its use most economical for handling fumes and gases in ventilating ducts and stacks, by reducing maintenance costs or replacements to a minimum.

For more severe duty, the pipe is also available with an impregnated or synthetic coating which offers adequate protection for many types of highly corrosive conditions.

Several types of synthetic-resin protection are offered with the pipe, each of which, as reported by the company, is suitable for a particular range of service, both in respect to the fluid to be handled and the mechanical severity of the operating conditions. The standard coating consists of an internal and external synthetic resin finish having a thickness of about 1/64". This coating is claimed to be extremely tough and durable and insures adequate protection for a great many corrosive conditions, including resistance to virtually all non-oxidizing acids. The company can also line Roxite pipe with Tygon corrosion resistant lining material, having an effective thickness of about 1/8". This lining thickness offers, it is said, high resistance to abrasion along with immunity against almost all corrosive chemicals, with the exception of glacial acetic, concentrated sulphuric and chlorinated solvents.

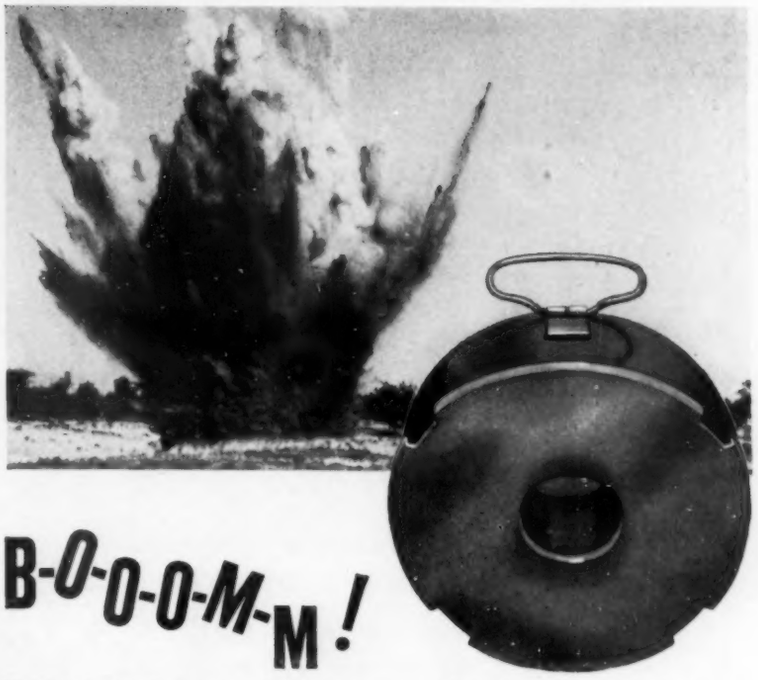
When the pipe is thus lined with Tygon, it is made to possess virtually all of the advantages of the firm's lined metal pipe. However, the standard unlined pipe in itself is said to be quite resistant to many corrosive fumes and gases that are encountered in chemical and process plants. Such fumes often attack lined metal pipe externally and not infrequently will then cause a pipe line to fail from the outside, in.

Specifications and Details: All the pipe, including the coated and lined types are available in any length up to 14 feet. The firm makes all sizes from 3/4" up to and including the 8" I.D. size. On special order, 10" and 12" I.D. sizes can also be secured. A complete line of standard fittings is available, including Ells, Tees, Y's, Crosses, Adapters, etc. Standard pipe lengths are easily cut in the field to any desired size with a simple abrasive saw arrangement. All of the pipe when de-aired, is said to be satisfactory for working pressures up to 150 lb. per sq. in.

Still for Recovery of Chlorinated Solvents

The necessity for full recovery of chlorinated solvents (used principally in vapor type degreasers) in industrial plants, due to O.P.M.'s order M-41 governing the restricted rationing of such solvents, brings a timely development by the Phillips Manufacturing Company of Chicago of an electrically operated and controlled, fully automatic, air-cooled, portable still.

Principal feature of these stills is that all heaters and controls are mounted integrally on the easily removed pot head, assuring easy cleaning and servicing, as well as easy access to the pot with no fixed fittings on the interior to trap solids.



B-O-O-O-M-M!

THIS field mine means business—and sudden destruction to any heavy equipment passing over it. It is one of the many small but effective instruments of war now being mass produced for our armed forces.

It is hard to believe that an instrument which can cause such havoc and debris and dirt must actually be cleaned before it is finished. But that is the case.

Cleaning field mines is just one of the many metal cleaning jobs done by Wyandotte for the Army these days.

Wyandotte men and materials are busy helping arsenals and metal industries to produce the materials of war swiftly and surely. If you have a problem in metal cleaning, there's a Wyandotte man waiting to help you.

Wyandotte PRODUCTS

SERVICE REPRESENTATIVES IN 88 CITIES

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CONTROL
SOLUTIONS
&
DEPOSITS

METAL IS TOO DIFFICULT TO OBTAIN TO WASTE IT

A complete line of Testing Sets for controlling solutions and testing deposits.

Complete laboratory service.

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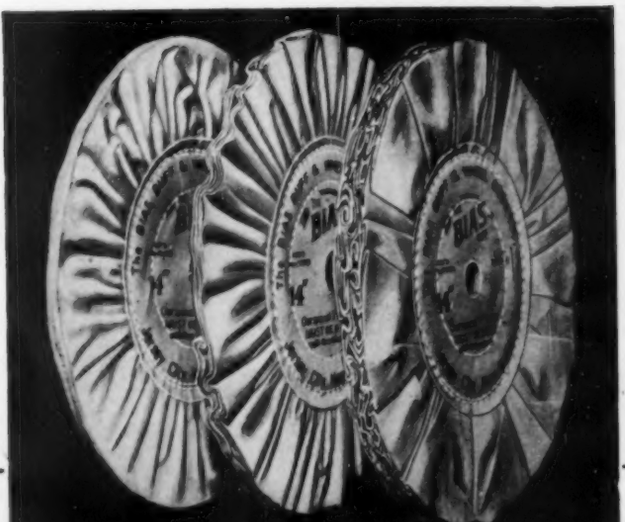

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Black-Magic baths for steel, iron, brass, copper, bronze, zinc die castings.

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In operation the still is plugged into a grounded circuit receptacle, and dirty solvent is then pumped or poured into the pot. A sealed float switch indicates by green pilot lamp when pot is full, and automatically energizes the heater and starts the cooling fan on the condenser tower. When liquid level drops to a point just above the heater, the float switch cuts off the heater and pilot lamp until a new charge of dirty solvent is placed in the pot. When the oil residues reach a predetermined specific gravity and temperature, indicating a 98% to 99% solvent recovery, the heater is de-energized, and a red pilot lamp signals the operator to dump the residue before again filling the pot.

The collector chamber of the condenser tower is fitted with a moisture trap to insure removal of water which may be in solution with dirty batches, and the clean solvent discharge pipe is at a level permitting draining into a standard drum lying on the floor.

The above described still produces 15 gallons per hour, operating on single or three-phase, 220 or 440 volts, 60 cycles A.C. is classified under maintenance equipment priority rules. Larger capacity stills in various sizes are also manufactured, operating under the same principles.

The unit is constructed to recover perchlorethylene, and can be modified to recover carbon tetrachloride and tri-clorethylene.

For further information write: Phillips Manufacturing Company, Dept. S, 340 W. Huron St., Chicago, Ill.

Alloy for Soldering Aluminum

Metalloy Co., Box 3093, Terminal Annex, Los Angeles, Cal., have announced the development of an alloy, which, it is claimed, enables the securing of a perfect soldering bond with aluminum or aluminum alloys.

The bond is obtained without the use of any flux. The surface to be coated or soldered is heated with a welding torch to about 600°F., and then a stick of the alloy is applied directly to the heated surface, allowing a small amount of the solder to flow onto the surface. A stiff wire brush is then used to brush briskly in all directions until a bright finish is secured. If a heavy deposit or build-up of metal is desired after the initial bond has been obtained, more of the material can be readily applied and agitated with a paddle or wire brush until the required thickness is obtained. The solder is also recommended for filling holes or defects in foundries.

The alloy is stated to bond with practically all types of metals, and thus it can be used for joining aluminum and other metals. It is also recommended for applying a protective coating to welded seams, and it is reported, that corrosion tests have shown that the alloy is satisfactory as a substitute for galvanizing.

Rust Proofing Process

Following publication of rumors and speculation on the possibility of a process to replace tin in the tinning of cans for food-stuffs, comes official announcement of aid to vital war production, by the Parker Rust-Proof Company, Detroit, in releasing for industrial use a new product for the replacement of tin in the treatment of steel sheets from which cans and other thin metal containers and closures are made. Already several steel companies and one manufacturer, who annually produces millions of bottle caps, are making installations of the production equipment necessary for use of the new product.

Production capacity of equipment now on order is estimated at 10,500,000 base boxes annually. A base box is 217.8 square feet of sheet. Use of the new Parker development will release several thousand long tons of tin for more vital war production. How much further this may go in conserving tin, cannot be foreseen at this time.

The new product, which will be identified under the present Parker trademark name of Bonderite "K", involves a new technique in application giving high-speed production. Instead of dipping or spraying, the steel sheets pass through all operations, Bonderizing, rinsing, and drying, on a series of rubber rollers with the dual capacity of conveyors and applicators. Handling is entirely automatic from feeding to packing the finished sheet.

The new Bonderite, as applied, produces a fine-grained phosphate coating, providing a rust-inhibiting steel "black plate" which, when lacquered or enameled, is successfully used in bending, drawing, crimping, lock-seaming and other forming operations, without serious loss of finish adhesion or effectiveness. With these qualities, the new Bonderizing is applicable for treatment of black plate for use in the manufacture of cans, bottle caps and a wide variety of containers.

Recognition is due one of the major can companies for the timely inspiration which stirred the Parker research organization's interest in such a development some years ago, since now it may be used to replace vitally important metal,

So-o-o Chlorinated Solvents are Short!

TWO VARIATIONS

Magnus Emulso-Dip and Magnus Emulso-Spray are two variations of the same new method.

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Either can be used in many instances on existing metal washing machines with little alteration.

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On many jobs, washing machines are not necessary. You can set up the necessary tanks and sprays yourself.

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Where volume and the nature of the job make a new washing machine necessary, we will design Magnus Emulso-Dip or Emulso-Spray Washing Machines to meet your problems.

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The Magnus Emulso-Cleaning Method replaces solvent or vapor degreasing. It actually costs less to do a better, quicker, more dependable job, even on smut and difficult dirts on which other methods fail.

This method has been successfully used for many months in defense plants all over the country.

It is applicable to *all* types of metal cleaning and can be used *without* heat on many operations.

If you are interested in sure-fire metal cleaning to insure steady, speeded-up production in the months ahead, write to us now for full details.

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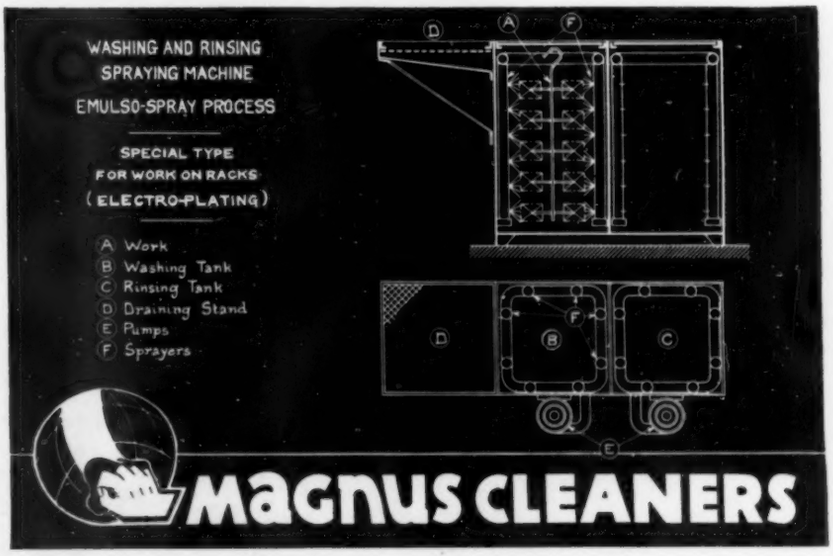

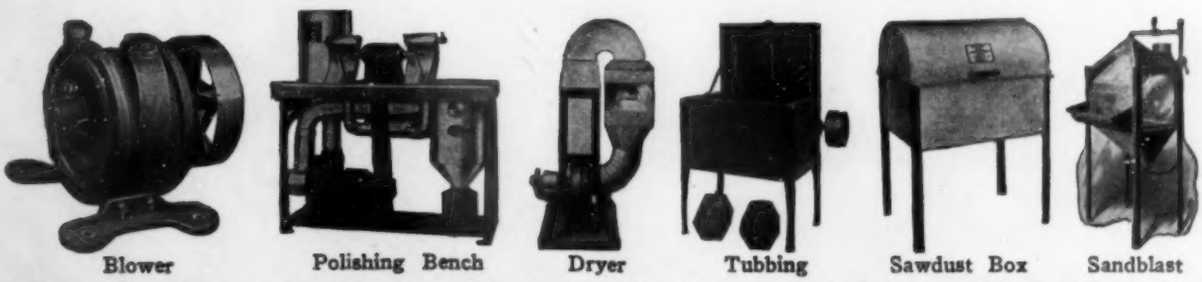

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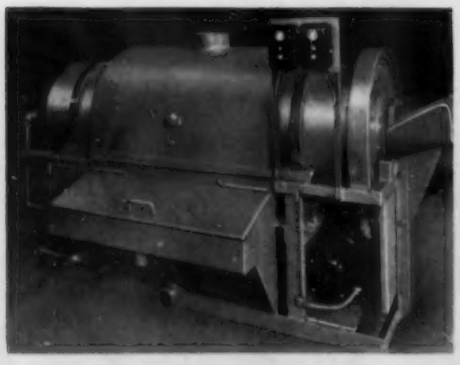

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N. RANSOHOFF, Inc. CINCINNATI, OHIO

of which America has such a limited supply. In actual tests of Bonderized black plate, Parker found, in collaboration with leading steel and can companies, that Bonderized black plate fabricates, ships, stores, and meets other packaging problems very successfully.

It was pointed out that while this new development was ready right at a crucial time, other Parker products, such as Bonderizing in its other forms, Parkerizing and Parco Lubrite, have, since the war began, been effecting untold savings in tin and other "priority" metals, including aluminum, chrome, nickel, cadmium, copper and zinc. While production of cars for civilian use has ceased, most of the present rolling equipment utilized these metal-saving materials, and future production for essential needs will undoubtedly continue their use. Typical examples are the replacement of tinned steel and aluminum pistons with steel pistons which are Parco Lubrized to have an oil-retaining, wear-resisting surface; the treatment of sheet metal and steel sash with Bonderizing in place of galvanzing, which, in total national consumption, provides substantial economy in precious zinc. Parkerized steel parts are taking the place of zinc-base die-cast hardware. Parkerizing or Bonderizing are replacing valuable cadmium on many important items, and their use on millions of pieces of armament and war equipment is again, in many instances, conserving strategic metals.

Tin Recovery from Tinned Cans

A process for recovering tin and steel from used tin cans, requiring no preparation of the cans on the part of the householder, or other users of canned commodities, can now be applied to large scale production, according to an announcement by Walton S. Smith, Vice President of the Metal & Thermit Corporation. This company has been operating a test plant at San Francisco for the last five years.

"The pilot plant is a complete unit with a capacity of over 6000 tons. From its operations, suitable methods have been worked out for the recovery of about 24 pounds of tin oxide and almost a ton of scrap steel per ton of discarded cans," Mr. Smith stated. "The tin oxide is readily smelted to a grade equivalent to Straits Tin. This is the grade of tin formerly secured from the Malay Peninsula, now in Japanese hands."

The San Francisco plant handles cans which are collected from the city of Oakland and nearby communities. It accepts empties just as discarded and does not require special preparation for collection. The processing unit comprises unloading equipment, inspection station, rotary screens for dirt removal, incinerator for charring cans to destroy fat, paper, lacquer and other combustibles and to separate the carbonaceous residue, shredding and prewashing equipment, storage facilities, and complete equipment for continuous detinning by the alkali process.

Rough estimates indicate that about 2,500,000 tons of tin cans are discarded annually in this country and that about 1,000,000 tons of these could be economically collected and detinned, yielding about 11,000 tons of tin and 900,000 tons of scrap steel.

Detinning of tin plate clippings obtained from can companies and other sources has been a well established industry for more than thirty years, but detinning of used cans has been impractical in peace times. Normally prices of both tin and steel scrap are comparatively low. Ordinarily, residual tin in scrap derived from cans is objectionable to steel mills. However, with imported tin no longer available and the present shortage of steel scrap, the usual objections do not hold and the used container can provide a source of worthwhile quantities of both metals.

The principal problems involved are those of collection, preparation and transportation of cans.

In areas where cans are to be collected for detinning, the cans would have to be kept separate from other refuse. It would also be advisable to shred the cans at collection centers so as to reduce their bulk for shipment to the plants. Location of plants of about 50,000 to 80,000 tons capacity near large centers of population appears the most practical solution to the transportation problem.

Announced plans to reduce by forty per cent the amount of tin going into containers would eventually reduce the amount of tin that could be recovered, but not for a year or two. In any event, the black sheet steel, which it is said will be substituted for tin plate in many of its present uses, could be reclaimed.

Manufacturers' Literature

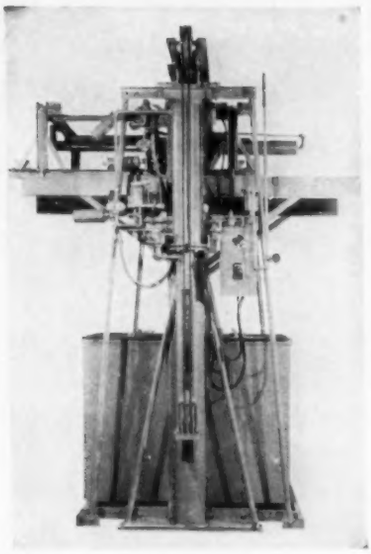
Burring of Metals

Lea Manufacturing Co., Waterbury, Conn., have recently issued a booklet describing burring of metals as developed by the company. This method involves the use of buffs or other wheels and special greaseless compositions developed by Lea Manufacturing Co. A chart is given showing recommended compositions, types of buffs and wheel speeds for burring various type articles used in the war program, including screw machine products, machine gun parts, gears, connecting rods, etc. A table giving surface speed of wheels for various diameters of wheels is given as well as specific directions on the use of the company's compounds.

Illuminated Magnifier

The George Scherr Company announces that it has just brought out a four-page folder fully describing the new Magni-Ray, an illuminated magnifier especially developed for close inspection of all parts

Crown Pick-up Unit



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FOR A SERIES OF OPERATIONS WHERE THE WORK MUST PASS THROUGH SEVERAL TANKS, AS THE CLEANING AND RINSING OPERATIONS, FOR A SEMI-AUTOMATIC PLATING TANK.

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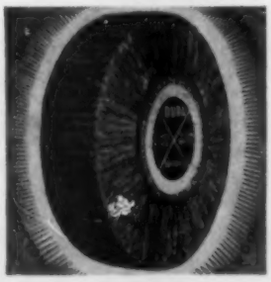

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entering airplane construction. The folder illustrates the Magni-Ray in use for all types of inspection of riveting, welding, repair and maintenance work, for inspection of small screw machine parts, stampings, spark plugs and other components entering airplanes.

Copies of this folder may be obtained from the George Scherr Co., 128 Lafayette Street, New York, N. Y.

pH Electrometers

Coleman Electric Co., Inc., 318 Madison St., Maywood, Ill., have recently published their 19-page bulletin No. 104, entitled, "New Instruments for a Modern World". This catalog describes and illustrates the various instruments for measuring hydrogen ion concentration.

Various types of electrodes and junctions are also described. There is an interesting section devoted to pH measurement for medical research with electrodes illustrated for measuring pH in the nasal cavity, for examination of wounds and a special assembly for measuring the pH of the stomach. Apparatus for electrometric titration are also illustrated.

Rust Preventive Oil

A new anti-rust oil, known as Miccroil, has just been introduced by the Michigan Chrome and Chemical Company, 6340 East Jefferson Avenue, Detroit. This material is said to have been developed as a rust preventive which will have many applications and is claimed to combine the best qualities of the most effective oils of its type.

Among its principal qualities is its high flash point. For this reason, the possibility of fire hazard is reduced to a minimum. It dries in 30 to 45 minutes which is extremely fast for a high flash oil. It is light in color, and transparent, and does not alter the appearance of the part on which it is applied. Miccroil is reported to contain no ingredients which produce a rancid odor.

Miccroil is applied by hand dipping, and is of a consistency which assures a uniform and extremely effective protective film over the entire surface. It contains 42.5% total solids. Once applied, it will provide constant protection until wiped off or removed with a solvent.

In a series of exposure tests reported by the company, steel panels coated with Miccroil were subjected to corrosive action of acid fumes in a typical plating plant where the relative humidity varied from 92% to 96% at 87° F. At the end of a month, no appreciable change could be seen in the protected surface. No deterioration was shown after 48 hours in a continuous spray of 20% salt solution, with the relative humidity at 96% and the temperature 80° F. No change could be noted after four weeks of exposure to the weather on the roof of a Detroit plant during the month of January.

This oil has been developed so that it may have innumerable uses—a feature which can make possible a reduction in the usual inventories of rust preventive

materials. It can be used on practically any surface which must be guarded from oxidation or corrosion. Aircraft, parts, gages, precision tools, other machined or polished parts, stampings, etc., can be protected with this material. It is said to have been found to be extremely valuable in plating plant use where a corrosive atmosphere is always prevalent. As an example, when the O. D. of a piece is plated and removed from the plating solution, the I. D. must be protected from corrosion immediately. Immersion in Miccroil protects the non-plated surface.

Miccroil is supplied in one gallon, five gallon containers, and 50 gallon drums.

Temperature Measurement and Control

A clear, concise explanation of how the national defense program affects purchase, use and maintenance of temperature measuring and control instruments is given in Defense Bulletin No. 1, issued by *Wheelco Instruments Co.*, Harrison & Peoria Sts., Chicago.

The bulletin, of six pages, has been issued to aid industrial instrument users in defense and non-defense industries to gain maximum life and efficiency from pyrometric equipment now installed and being installed. It will be supplemented by similar informational bulletins, if required.

Defense Bulletin No. 1 is designed to aid all users of pyrometers, regardless of make, to maintain equipment so it will operate efficiently and give uninterrupted service. It suggests substitute materials that may be employed in place of materials made critical because of the war program, and compares the properties of the original and substitute materials.

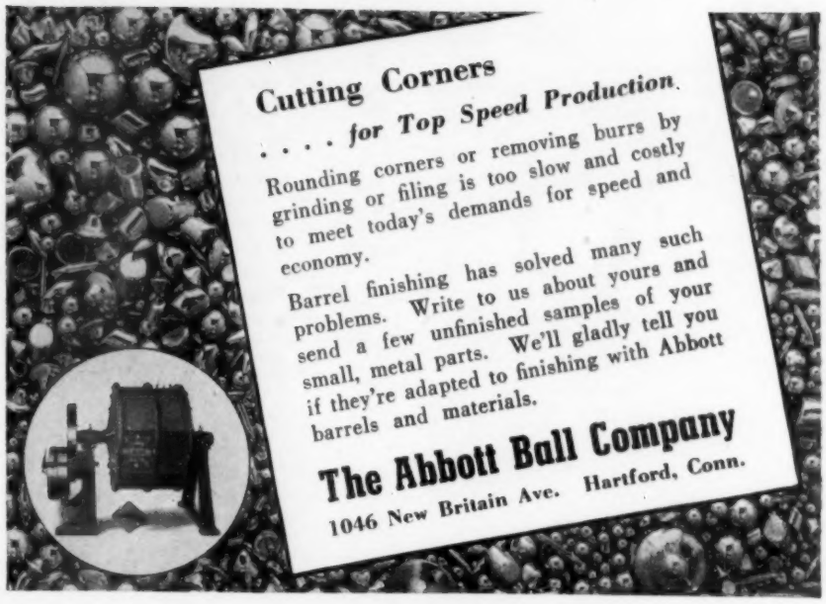
Copies may be had by addressing the company.

New Books

Practical Arc Welding. A textbook by W. J. Chaffee. 516 pages. 512 illustrations. Flexible, red fabrikoid cover. Copyright 1942. Published by Hobart Trade School, Inc., Troy, Ohio. Obtainable from the publisher, or an authorized Hobart distributor, or at most book stores. Price postpaid anywhere in the United States $2.

Arc welding today is U. S.'s seventh largest industry and the Allies most important defense tool. Even experienced welders find that they must keep abreast of modern procedures and techniques at all times so that they may successfully perform the increasing variety of jobs they daily must accomplish. For these reasons, this complete handbook of practical arc welding was written.

Part I in the book is devoted to general welding information. Material covered includes the growth of arc welding; where arc welding is used; manufacturing applications; available metals and alloys; discussion of joints and welds; electrodes and filler rods; strength of arc welded joints; cost of arc welding; characteristics of the welding arc; welding symbols and their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Rounding corners or removing burrs by grinding or filing is too slow and costly to meet today's demands for speed and economy.
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use; equipment for arc welding; development of welding personnel.

Parts II and III of the textbook are devoted to the complete series of arc welding lessons exactly as they are offered in the famed Hobart Trade School. This group of 41 lessons covers preliminary instructions; starting and manipulating the arc; common joints with bare electrodes; welding light gauge sheets with coated electrodes; welding with coated rods in all positions; pipe welding; welding cast iron; special tests; welding with the carbon arc; "long arc" method of welding copper; and specialized applications of arc welding.

Parts IV and V contain a complete dictionary of welding terms and twenty pages of helpful tabular data for operators and designers. The handbook also has an eight page cross reference index for the reader's convenience.

This new handbook is easily comprehensible to beginners yet it contains a wealth of practical arc welding data and lessons for the technical man. Welders, potential welders, students, instructors, designers, engineers will find this text invaluable for reference or home study work. The author has been very successful in his attempt to offer the thousands of men now interested in arc welding a textbook jammed full of fundamentals and modern welding procedures.

Condensed Chemical Dictionary. Third edition. Compiled and edited by the Editorial staff of the Chemical Engineering Catalog, Francis M. Turner, Editorial Director. Published by Reinhold Publishing Corp., New York. Sixe 9¼" x 6¼"; 755 pages. Price $12.00.

This well known text has had over 6,000 new items added to the second edition, thus making a total of over 18,000 different items discussed. These items include chemicals, drugs, raw materials, trade and brand names. Considerable data are given for each substance listed and not a simple definition in the ordinary dictionary sense. The subject matter for each chemical includes color and properties, solubility, derivation, grades, containers and uses.

In addition to the standard chemicals and raw materials are given proprietary names of various raw materials and finished products. In the appendix are many valuable tables, such as atomic weights, temperature conversion, specific gravity, boiling points, flash points, dissociation constants, resistivity of electrolytes and metal gauges. Definitions of various units are also given. Mention should be made of the section devoted to the pronunciation of chemical words, which should be read by all those using chemical terminology.

This book should be of value to chemists, chemical engineers, buyers and sellers of chemicals and to those associated with the industry.

A.S.T.M. Standards on Copper and Copper Alloys

This new publication of the American Society for Testing Materials first issued in December, 1941, provides in convenient form for ready reference the various specifications and tests issued by the Society covering copper and copper base products. The compilation sponsored by Committee B-5 on Copper and Copper Alloys, Cast and Wrought, also includes specifications developed by Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors and selected specifications prepared by Committee B-2 on Non-Ferrous Metals. There are some 73 standards covering a wide range of very important products, many of which are essential in the present National emergency program.

No other Society group has been more active than Committee B-5 in cooperating with service branches of the Government in order that adjustments might be made to bring specification provisions into substantial agreement. This has had the valuable result of making it possible to divert important products from regular commercial production to the emergency program.

Twelve specifications cover various types of wire and cable for electrical conductors. Eight give important requirements for various types of non-ferrous metals such as electrolytic copper, fire-refined copper, slab zinc, pig lead, nickel, lead-coated copper sheets, and a proposed draft covering oxygen-free electrolytic copper wire bars, billets, and cakes.

Sixteen standards cover various types of plate, sheet, and strip, including cartridge brass, gilding metal, gilding metal bullet jacket cups, bridge bearing and expansion plates, phosphor bronze, beryllium-copper materials, and Muntz metal.

The field of wire rods, bars and shapes (not electrical conductors) is covered by 15 specifications. There are nine for various types of pipe and tubes—copper and brass boiler tubes, standard pipe, copper seamless tubes and water tubes. The 16 specifications for copper, base alloys for sand castings include the important classifications of cast copper base alloys.

Among the standard tests are the new expansion (pin test) test for tubing and the mercurous nitrate test for copper alloys. Also given are the standard tension and hardness tests and the extensive methods of preparing micrographs of metals and alloys, with the insert plate showing grain size standards.

Copies of this 350-page new publication in heavy paper cover can be obtained from the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa., at $2.00 per copy. Reduced prices on orders in quantity.

Technical Publications

Steel Products Manual. Carbon-Steel Wire. Section 16. American Iron and Steel Institute, 350 Fifth Ave., New York. February 1942. Price, 25c per copy, post-paid.

Steel Products Manual. Stainless Steel. Standard Type Numbers and Composition Ranges Corresponding Thereto. American Iron and Steel Institute, 350 Fifth Ave., New York. February 1942.

Contributions to the Metallurgy of Steel—No. 5. Possible Alternates for Nickel, Chromium and Chromium-Nickel Constructional Alloy Steels. American Iron and Steel Institute, 350 Fifth Avenue, New York. January 1942.

This book is valuable in view of the necessary substitution of nickel-chromium steels by non-alloy or other alloy steels. Various prominent metallurgists assisted in compiling this information. Alternates for nickel-chromium steels in this booklet embrace a series of carbon-molybdenum steels, manganese-molybdenum-steels and also low chromium-molybdenum and low nickel-chromium-molybdenum steels. The use of the alternate steels, the booklet states, may make necessary some changes in established meth-

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ods of fabrication or heat treament procedures, or both, or may even make necessary some changes in engineering design of the product affected.

Specifications Booklet

The Hanson-Van Winkle-Munning Company of Matawan, N. J., manufacturers of electroplating equipment and supplies have issued a new edition of a booklet which includes specifications for electrodeposited coatings of zinc, cadmium and nickel on steel; nickel and chromium on copper and copper base alloys; nickel and chromium on zinc and zinc base alloys; also methods of testing for local thickness of electrodeposited coatings. These are the tentative specifications of the American Society for Testing Materials, prepared jointly by the American Electroplaters' Society, the National Bureau of Standards and the American Society for Testing Materials.

The booklet is neatly bound between two stiff paper covers to keep in good repair a collection of data which is indispensable to every producer of electroplated metal products.

Associations and Societies

American Electroplaters' Society

Annual Branch Meetings

Boston Branch

Time—Saturday, March 28.
Place—Hotel Statler, Boston, Mass.
Joe Barron, 143 Sidney St., Cambridge, Mass., General Chairman.

Newark Branch

Time—Saturday, April 11.
Place—Hotel Robert Treat.
Educational Session—2:30 P.M.
Banquet—7:30 P.M.

Buffalo-Rochester Branches

A joint meeting of the branches will be held on Saturday, Apr. 18 at the Hotel Seneca, Rochester, N. Y.

The educational session will start 2:00 P.M., and the speakers will be *Gustaf Soderberg*, Udylite Corp., Detroit, Mich., *W. A. Helbig*, Darco Corp., New York, N. Y., and *R. O. Hull*, Dupont Co., Cleveland, Ohio.

Indiana-Ohio Branches to Hold Joint Meeting

The Dayton-Cincinnati-Anderson and Indianapolis Branches of the Society will hold a joint meeting on March 21st in Indianapolis.

The educational session will be held in the afternoon followed by a dinner. The affair will be stag and informal.

For further information contact, *W. R. Binai*, vice-president, Indianapolis Branch, 520 N. Bancroft St., Indianapolis.

Los Angeles Branch

A large number of representatives from the metal finishing and plating departments of Lockheed, Vega, North American and Douglas aircraft factories and the Curtis-Wright Co., attended the February 11 meeting of Los Angeles Branch, A.E.S., to hear *Richard P. Crane*, vice-president and sales manager of the Lea Manufacturing Co., Waterbury, Conn., discuss aspects of metal polishing and burring as they apply to airplane plants.

Mr. Crane spoke on the Lea method of burring. Opening with a discussion of the evolution of polishing and the steps that have brought that phase of the craft to its present status, Mr. Crane declared that during the past 15 years the emphasis has been toward covering up rather than removing defects so as to obtain as uniform a finish as possible. The industry, he pointed out, is not so concerned with corrosion resistance as it is with what can be accomplished with polishing. He concluded with a discussion of disc flexible head polishing and burring.

Herold Kroesche of the A. J. Lynch Co. delivered an extemporaneous talk on "A New Decorative Finish" in which he dealt with a recently introduced silver depositing method which, he declared, may signify a new trend in plating.

While the process, according to Mr. Kroesche, is not yet developed to a stage where it will be practical for a job shop engaged in small production, it is designed for use primarily on steel as the most available base metal, and also on copper, die castings and brass.

Mr. Kroesche briefly discussed the type of bath required for silver depositing on steel by this method, the depth of deposit and other factors. The method thus far, he emphasized, has been found adaptable as a decorative finish on articles like toaster, waffle irons, light fixtures, and the like, which are not subject to excessive strain. Samples of finished items were shown.

Annual Meeting

B. G. Daw, president of Lasalco, Inc., St. Louis, and *J. A. Raskin*, chemical engineer of the Udylite Corp., Detroit, head an imposing list of speakers who will address members of Los Angeles Branch, A.E.S., at the 1942 annual educational session to be held Saturday, March 21, at the Los Angeles Breakfast Club.

Mr. Daw will present a paper entitled "What Happens Inside a Plating Barrel," which will be illustrated by motion pictures. Mr. Raskin will talk on "Conservation of Plating Materials."

Southern California speakers who will present the balance of the program are the following:

"Aircraft Electro-Finishing," by *Robert R. Janssen*, process engineer, North American Aviation, Inc., Inglewood, Calif.

"Outline of a New Silver Deposition Method and its Uses as a Decorative Finish," by *Herold Kroesche*, A. J. Lynch Co., Los Angeles.

"The Relation between Water Conservation and Plating," by *James P. ApRoberts*, Turco Products, Inc., Los Angeles.

The morning and afternoon sessions, the products exposition and the annual dinner and dance will be held in the spacious quarters of the Los Angeles Breakfast Club, scene of the 1941 affair.

This year's general chairman is *Marcus Rynkofs*, with *Don Bedwell* as assistant chairman. *Ernest Lamoureux* is conducting negotiations with out-of-town speakers. *Emmette R. Holman* is making the arrangements for local speakers. *James ApRoberts* is handling the exhibit of finished products, assisted by *Stanley Rynkofs*, *Ed Wells*, *Erwin Frauenhoff* and *Frank Rushton*.

It was announced that the Los Angeles Breakfast Club has facilities available for carrying on the annual banquet in the evening in the event of a blackout.

Members of Los Angeles Branch, A.E.S., are responding wholeheartedly to an invitation by Southern California airplane manufacturers to contribute books, papers and other technical material on metal finishing, polishing and plating subjects to a new co-operative research library which the aircraft manufacturers of the Los Angeles area have established in Hollywood.

The library is organized as a non-profit enterprise open for study and research by all employees of aircraft plants. Los Angeles A.E.S. Branch appointed Vice-president *James ApRoberts* as chairman of a committee to assemble back copies of the *Monthly Review*, *Metal Finishing*, and other publications and pamphlets dealing with plating and organic finishing of metals, for presentation to the research library.

Business Items

Whittaker, Clark & Daniels, Inc., 260 W. Broadway, New York City, co-owner of the *Pumice Corp. of America*, producers of Valencia pumice stone, announce the completion of a new installation at their pumice grinding plant, and a complete modernizing of the mining and cleaning mill equipment at Grants, N. M., to further take care of the demand for a high quality pumice stone.

The Lea Mfg. Co., Waterbury, Conn., has taken over sales and distribution in Southwestern New England of the Paasche line of lacquer and paint spraying equipment made by *Paasche Airbrush Co.* of Chicago.

H-V W-M Insignia Awards for Service

Public recognition for service of employees has been instituted by the Hanson-Van Winkle-Munning Co., Matawan, N. J., manufacturers of electroplating equipment and supplies. Service badges have been awarded to all of the employees who have been with the Company for five years or

H-VW-M service insignia. Upper, button for men. Lower, pin for women.

more. Various lengths of service are indicated by the different materials used for the badges, although the design as shown by the illustrations, is standard throughout.

Women receive the same recognition as men. The men's badges are in the form of a button which fits into the coat lapel; the women's, made up as a pin. Men's badges show the number of years service.

The materials used for the insignia for different lengths of service are as follows:

Five years—Bronze with numeral 5 (for men).

Ten years—Sterling silver with the numeral 10 (for men).

Fifteen years—Gold with the numeral 15 (for men).

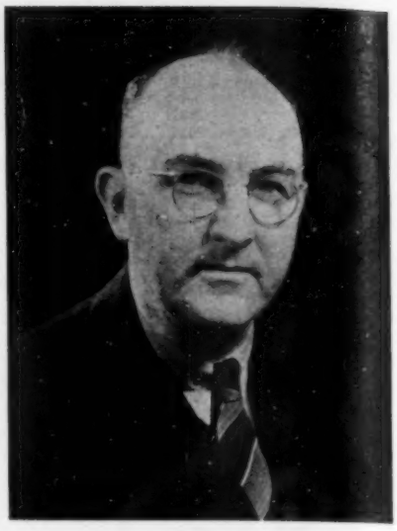
Twenty years—Gold and enamel with the numeral 20 (for men).

Twenty-five years — Gold and enamel, with a diamond instead of the numeral.

The Company is well fitted to appreciate the value of long service, as its own service to the electroplating industry has been rendered continuously since 1820—a matter of 122 years.

Oakite Appoints Co-ordinator of War Industries Work

Oakite Products, Inc., 22 Thames St., New York, N. Y., have announced the appointment of *A. H. Bond* as co-ordinator of the company's War Industries Work. Through Mr. Bond, information on the latest developments in production cleaning and related manufacturing operations essential to the manufacture of artillery, tanks, airplanes, rifles, shells, cartridge cases, helmets and other direct war goods, will be made readily available to various Government officials and manufacturing executives.



A. H. Bond

Mr. Bond is a graduate of North Carolina State College, with a degree in mechanical engineering and he has had experience with the U. S. War Department and with a large Midwestern manufacturing company before becoming an Oakite service engineer in 1928. His headquarters will be 757 N. Broadway, Milwaukee, Wis., but he will cover Washington and key production centers throughout the country.

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Supply Prices, March 2, 1942

Anodes

Prices are f.o.b. shipping point on quantities of from 500-999 lbs. for copper, brass and zinc. For nickel, prices are for quantities from 500-2,999 lbs.

COPPER: Cast, elliptical, 15″ and longer	25⅛c. per lb.	ZINC: Cast, 99.99, 16″ and over	16¼c. per lb.
Electrolytic, full size, 22⅞c; cut to size	22⅞c. per lb.	NICKEL: 95-97 cast, elliptical 46c. per lb., 99% plus cast 47c.; rolled, depolarized	48c. per lb.
Rolled, oval, straight 15″ and longer 23¼c. per lb.; curved	24¼c. per lb.	SILVER: Rolled, .999 fine per Troy oz.	38c. per oz.
BRASS: Cast, 80-20, elliptical, 15″ and longer	23⅝c. per lb.		

Chemicals

These are manufacturers' quantity prices and based on delivery from New York City.

Acetone, C.P., drums, l.c.l.	lb.	.09-.178
Acid, Boric tech., 99.5% gran., bbls.	lb.	.063
Chromic, 99%, 100 lb. drums, l.c.l.	lb.	.18¼
Hydrochloric (muriatic) tech., 20°, carboys, wks	lb.	.0270
Hydrochloric, C.P., 20°, bottles	lb.	.19
Hydrofluoric, 30% bbls.	lb.	.06-.06½
Nitric, 36°, carboys 1-9, wks.	lb.	.0595
Nitric, 42°, carboys 1-9, wks.	lb.	.0745
Oleic (Red Oil), distilled, drums	lb.	.12¾-.14
Oxalic, bbls. l.c.l.	lb.	.14½
Stearic, distilled, double pressed, bags	lb.	.15-.16½
single pressed, bags	lb.	.14½-.16
triple pressed, bags	lb.	.17¾-.19¼
Sulphuric, 66°, carboys 1-9, wks.	lb.	.0245
Alcohol, Amyl (Fusel oil, ref'd), l.c.l., drums	lb.	.18-.18½
Butyl-normal, l.c.l., drums	lb.	.13½-.168
Denat., S.D. #1, 190 pf., 1-18 drms., wks.	gal.	.65
Diacetone, tech., drums, l.c.l.	lb.	.11-.13½
Methyl, (Methanol), 95%, drums, l.c.l.	gal.	.37
Propyl-Iso, 99%, drums, l.c.l.	gal.	.47
Propyl-Normal, drums, wks.	gal.	.67-.70
Alum, ammonia, granular, bbls., works	lb.	.04
Potash, granular, bbls., works	lb.	.0425
Ammonia, aqua, 26°, carboys	lb.	.05¼
Ammonium, chloride (sal-ammoniac), white, granular, bbls., wks.	lb.	.0675
Sulphocyanide (thiocyanate), pure, crystal, kegs	lb.	.55
Sulphocyanide (thiocyanate), tech., kegs	lb.	.40
Antimony Chloride (butter of antimony), sol., carboys	lb.	.17
Barium Carbonate, pptd., bags, l.c.l., works	lb.	.03
Benzene (Benzol), 90%, drums, works	gal.	.20
Butyl Lactate, drums	lb.	.265
Cadmium Oxide, l.c.l., bbls.	lb.	.95
Calcium Carbonate (Pptd. chalk), c.l., wks.	lb.	.02⅞
Carbon Bisulphide, l.c.l., 55 gal. drums	lb.	.05¾
Carbon Tetrachloride, l.c.l., drums	gal.	.80
Chromic Sulphate, scale, 100 lb. drums	lb.	.45
Cobalt Sulphate, drums	lb.	.71
Copper, Acetate (verdigris), bbls.	lb.	.26
Carbonate, 52-54%, bbls.	lb.	.16½
Cyanide, Tech., 100 lb. bbls.	lb.	.34
Sulphate, 99%, crystals, bbls., 1-5	lb.	.0535
Cream of Tartar (potassium bitartrate), gran., kegs	lb.	.58½
Crocus Martis (iron oxide) red, bbls.	lb.	.03¼
Dibutyl Phthalate, drums, l.c.l.	lb.	.215-.235
Diethylene Glycol, drums, l.c.l., works	lb.	.155
Dextrin, white, bags, F.O.B. Chicago	lb.	.0395
Emery (Turkish)	lb.	.08
Ethyl Acetate, 85%, l.c.l., drums, works	lb.	.12-.13
Ethylene Glycol, l.c.l., drums, works	lb.	.15½-.18½
Monoethyl ether, dms., l.c.l., wks.	lb.	.15½-.16½
Gold, Chloride, yellow, bottles	oz.	$19.25
Cyanide, potassium 41%, bottles, wks.	oz.	$14.20-$14.95
Gum, Arabic, white, powder, bbls.	lb.	.33-.35
Hydrogen Peroxide, 100 volume, carboys	lb.	.16-.18½
Iron Sulphate (Copperas), cryst., bbls., 1-4 wks.	lb.	.02
Lead, Acetate (Sugar of Lead), crystals, bbls.	lb.	.12½
Oxide (Litharge), com., powdered, bbls.	lb.	.09
Magnesium Sulphate (Epsom Salts), tech., bbls.	lb.	.019
Mercury Bichloride (Corrosive Sublimate), crys.	lb.	$2.39
Mercuric Oxide, tech., red, powder, bbls.	lb.	$3.11
Nickel, Carbonate, dry, bbls.	lb.	.36-.36½
Chloride, bbls.	lb.	.18-.20
Salts, single, 425 lb. bbls.	lb.	.135-.145
Salts, double, 425 lb. bbls.	lb.	.135-.145
Paraffin, refined, bgs., 123-125 a.m.p., c.l.	lb.	.0520
Perchlorethylene, drums, l.c.l.	lb.	.08½
Phosphorus, red, cases	lb.	.44
yellow, cases	lb.	.23-.25
Potash, Caustic, 88-92%, flake, drums, works, c.l.	lb.	.07¼
Potassium, Bichromate, crystals, casks	lb.	.10
Carbonate (potash) calc., wks., drums	lb.	.06¾
Cyanide, 94-96%, dom. dms., wks.	lb.	55
Pumice, ground, 1½ F. & coarser, bbls., wks.	lb.	.04½
Quicksilver (Mercury), dom. 76 lb. flasks, net	flask	$191-$193.
Rochelle Salts, crystals, bbls.	lb.	.44
Rosin, gum, D bbls., dock	lb.	.0345
Silver, Chloride, dry, 50 oz. lots	oz.	.38⅞
Cyanide, 100 oz. lots	oz.	.34
Nitrate, 100 oz. lots	oz.	.27⅛
Sodium, Carb. (soda ash), light, 58%, bags	lb.	.0213
Cyanide, 96%, dom. 100 lb. drums	lb.	.15
Hydroxide (caustic soda) 76%, flake, l.c.l.	lb.	.0490
Hyposulphite, crystals, bags, wks.	lb.	.0250
Metasilicate, granular, 1-9 bbls.	lb.	.0335
Nitrate, rfd., gran., bbls., wks.	lb.	.029
Phosphate, tribasic, tech., bbls., wks.	lb.	.038
Pyrophosphate, anhydrous, bags, l.c.l.	lb.	.0660
Sesquisilicate, 1-9 drums	lb.	.0430
Stannate, drums	lb.	.365
Sulphate, anhydrous, bbls., works	lb.	.0240
Sulphocyanide, drums	lb.	.55-.65
Sulphur, Flowers, U.S.P., bbls., l.c.l. mine	lb.	.039
Tin Chloride, crystals, kgs.	lb.	.39-.39½
Toluene (Toluol), 2°, ind., drums, works	gal.	.33
Trichlorethylene, drums, l.c.l., zone 1	lb.	.08½
Tripoli, air floated, bgs., c.l., wks.	ton	$21.00
Wax, Bees, white, bleached, slabs, 1-5 cases	lb.	.61
Bees, yellow, crude, Brazil, 100 lbs.	lb.	.50
Carnauba, refined, bags	lb.	.85
Montan, bags	lb.	.45-.46
Spermaceti, blocks	lb.	.26-.27
Whiting, precipitated, bags, l.c.l.	ton	$18.-$22
Xylene (Xylol), ind., returnable drums, works	gal.	.32
Zinc, carbonate, tech., bbls.	lb.	.20
Cyanide, 100 lb. kegs	lb.	.37
Chloride, tech., granular, drums, c.l., wks.	lb.	.08
Sulphate, crystals, bbls., l.c.l.	lb.	.039

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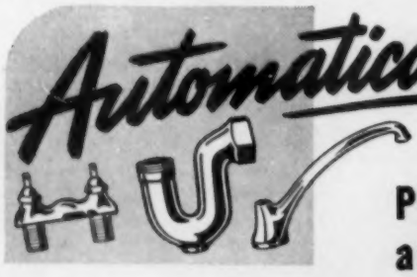

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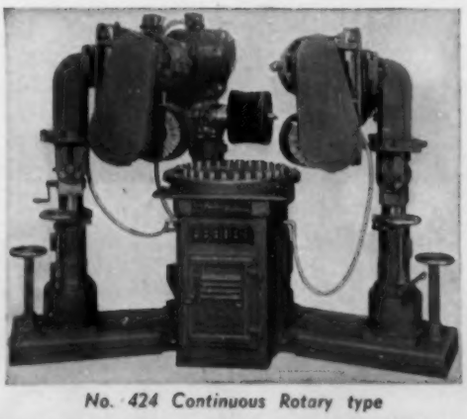

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